

**A WEB-BASED GIS AS A MANAGEMENT TOOL FOR
ROCK ART SITES IN THE UKHAHLAMBA –
DRAKENSBERG PARK**

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Abstract

The importance of managing and conserving cultural heritage can not be overemphasised. It is this realisation that has prompted the United Nations Educational, Scientific and Cultural Organisation (UNESCO) to declare identified sites of cultural importance as World Heritage Sites. The uKhahlamba–Drakensberg Park (UDP) was declared such a site in 2000, with its natural properties and cultural heritage as the criteria for inscription. The cultural heritage centres on the vast quantity of rock art that is renowned for its quality and diversity of subject. It is an important consideration for future generations to have the opportunity to view and understand this rich history and culture. There are increasing human and natural impacts on this non-renewable resource and to minimise these impacts and thus ensure the longevity of the resource it is necessary to develop a multi faceted selection of management and conservation tools. This realisation led the Programme of Geomatics, University of KwaZulu-Natal to conceptualise a project to develop a web-based Geographical Information System (GIS) specifically aimed at assisting in the management and conservation of rock art sites for the Valley of Pools in the Cathedral Peak Conservation Area of the UDP. Data for the project was captured in the field using Global Positioning System (GPS), digital camera and video camera as well as conventional hardcopy documentation. Existing digital spatial data and descriptive data were also collected from relevant stakeholders and a commercial organization. A pilot spatial database was then developed using ArcGIS^{®9} and Microsoft Access[®], and later tested using a set of integrated simulated queries reflective of routine questions that users may request. Upon obtaining satisfactory responses to the queries, the integrated database was migrated and authored in ArcIMS^{®9} where it was further tested, and subsequently access was given to selected external professionals, both nationally and internationally, from various backgrounds, for evaluation purposes. Feedback from this process was favourably obtained.

Preface

The research described in this mini-dissertation was carried out at the Centre for Environment, Agriculture and Development, University of KwaZulu-Natal, Pietermaritzburg, under the supervision of Mwitwa Chilufya.

This mini-dissertation represents the original work of the author and has not otherwise been submitted in any form for any degree or diploma at any university. Where use has been made of the work of others it is duly acknowledged in the text.



Signed: (Carl Grossmann - candidate)



Signed: (Mwitwa Chilufya - Supervisor)

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I would also like to state that such a project as this was not entered into lightly. I knew that the electronic mapping and presentation of the last remains of the culture of Africa's 'First People' was an awesome responsibility. These paintings are a religious expression of a long lost culture and before the project started I entered the mountains seeking a sign of approval and believe that was granted at Injasuti in 2003. The responsibility of having a part to play in bringing change to the way in which this national treasure is conserved and managed weighs heavy on my shoulders now and into the future as the job is not done, but has only just begun. I tread forward with nothing but respect.

I would also like to acknowledge the intersection of life paths, some mere moments, some decades old, every one important in its own way, that have brought me to this place and time.

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1. Introduction

The Rock Art Mapping Project (RAMP) is a major multi faceted rock art documentation and distribution project conceived and implemented by the Programme of Geomatics (Land Surveying), Howard College Campus, University of KwaZulu-Natal, South Africa. RAMP received funding from the South African National Lotteries Distribution Trust Fund (NLDTF) in July 2003 to achieve the following four key objectives, namely:

1. To digitally archive and map all the rock art sites within the Ukhahlamba Drakensberg range using terrestrial photogrammetry and/or laser scanning.
2. To create a Geographical Information System (GIS) website for researchers and educational institutions which will record, inter alia, the condition and location of each site as well as provide an accurate source of mapping data that can be used for research purposes. An aspect of this website (or an additional stand alone website) will display the national heritage to the general public in a way that protects the location of such sites and meets all security issues.
3. To place a team in the field for a long period of time with the sole aim of conducting a detailed exploration of the area for additional, unrecorded rock art sites.
4. To create long term permanent employment opportunities within the local community which would involve eco-tourism and training.

This thesis concentrates on the partial achievement of objective number two.

The rock art legacy of the Southern African San, or “First People”, is displayed to us on the fragile and vulnerable rock surfaces of many hundreds, if not thousands, of rock shelters and caves spread throughout the country. This art work not only displays images of everyday life, clan culture, various animals and natural scenes but also depicts the very complex and integrated spiritual thoughts and beliefs of this old culture. Recent dating of these paintings in the Ukhahlamba-Drakensberg Park reveal that they age anything from 3000 years ago to a mere few hundred years ago (Mazel and Wachman 2004).

There are an estimated 40,000 paintings at some 550 sites in the Ukhahlamba-Drakensberg Park (Wahl *et al.* 1998). The Ukhahlamba-Drakensberg Park is situated to the west of the province of KwaZulu-Natal in South Africa and shares a border with the country of Lesotho. It was declared a World Heritage Site (WHS) in 2000 (UNESCO Undated). It is listed under two categories, namely Natural Properties, criteria (iii) (iv) and Cultural Heritage, criteria (i) (iii) (UNESCO Undated). Of relevance to this project is the cultural heritage for which the inscription is as follows:

“Criterion (i): The rock art of the Drakensberg is the largest and most concentrated group of rock paintings in Africa south of the Sahara and is outstanding both in quality and diversity of subject.

Criterion (iii): The San people lived in the mountainous Drakensberg area for more than four millennia, leaving behind them a corpus of outstanding rock art which throws much light on their way of life and their beliefs.”

(UNESCO)

This rich cultural history, in most parts, is poorly documented and inaccessible to the majority of South Africans. Sensitive heritage material needs to be protected, but needs to be documented first to ensure a record remains intact. The most exposed and frequented sites occur in the region controlled by Ezemvelo KwaZulu-Natal Wildlife (EKZNW), visited by some thousands of tourists annually. With the declaration as a WHS, this traffic is set to increase and without a defined database of sites, irreparable damage could be done and a valuable part of South Africa’s heritage lost forever.

Through the fieldwork of RAMP the complete digital documentation of the Ukhahlamba-Drakensberg Park is underway. This digital documentation consists of the following components for each rock art site.

- A detailed written record stored in an extensive Microsoft Access database.
- Rectified digital imagery.
- Rectified digital orthophotograph mosaics of the rock art panels.
- Digital 360° videography.
- Digital topographical image of each site as well as downloadable .dxf format.
- Digital 3D virtual fly-through model.

With the advent of the internet or world wide web (www) and the proliferation of hardware and software technology in the 1990's it is now possible to collate this data in the form of a Geographic Information System (GIS) and serve this vast array of digital, spatially georeferenced data to a specified specialist interest group, with the correct security clearances, or even to the general public if so desired.

1.1 Problem Statement

The Natal Museum is considered the official provincial custodian of the rock art data set for KwaZulu-Natal. At present this archive consists of a set of 1:50000 scale paper mapsheets that show the location of rock art sites with the presence of a dot and a unique reference number written on the mapsheet. This unique reference number is used to reference a paper filing catalogue system where the written records and documentation on each site is kept. Should there be any visual documentation on a site such as photos, tracings or slide transparencies, their location in a fire resistant strong-room is indicated in the written record (Swart 2004 pers. comm.). Should a researcher wish to access any of this data he or she has to proceed through a physical process that is time consuming, elaborate and a danger to the actual archive should any of this material be damaged or lost while in the custody of the researcher. The museum has just completed transferring their written records into a custom designed Microsoft Access® Database. The database was constructed to include all of the fields that were present on the written recording sheets. These fields may not be adequate to accommodate the broad base of research needs in the future and holds little management and conservation data on each site.

Amafa aKwaZulu Natali (Amafa) are the legal managers and conservators of the archaeological heritage in KwaZulu-Natal. They do not hold any hard copy material on rock art sites and rely entirely on the Natal Museum and their long history of archival and recording of rock art. What few records Amafa hold is in paper form with few systems in place (Wintjes 2005 pers. comm.) Any management or conservation effort involves field investigations on a case by case basis.

2. Aim and Objectives

2.1 Aim

This project will develop a web-based GIS as a management tool for the rock art of the Ukhahlamba-Drakensberg Park, KwaZulu-Natal, South Africa. It will achieve this by integrating and delivering, via the internet, a variety of relevant datasets for use by various organizations and people.

2.2 Objectives

The following objectives will be achieved by this project:

1. The establishment of an internet server that will host and serve a web-based GIS containing a sufficient number of spatial datasets, inclusive of the under listed, accessible to various authorities for processing and analysis according to various criteria in support of management decisions.
 - 1: 10 000 scale seamless orthophotographs of the study area within the Ukhahlamba-Drakensberg Park
 - Geographic positions of various types of archaeological sites
 - Major paths and rivers
2. Development of a Microsoft Access[®] Database containing site details
3. Linking of spatial data layers and Microsoft Access[®] Database to facilitate integrated queries

3. Hypothesis

A web-based GIS can be used as a management tool for rock art sites in the Ukhahlamba-Drakensberg Park by Amafa, EKZNW and the Natal Museum.

4. Literature Review

4.1 Legislation

Placing South Africa's heritage within the international context is the 1972 Convention Concerning the Protection of the World Cultural and Natural Heritage (referred to as the World Heritage Convention) organised under the auspices of the United Nations Educational, Scientific and Cultural Organisation (UNESCO). Chapter 3 Article 8 makes provision for the establishment of the World Heritage Committee which is comprised of up to 21 member state parties as well as a representative of the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), a representative of the International Council of Monuments and Sites (ICOMOS) and a representative of the International Union for Conservation of Nature and Natural Resources (IUCN). These three representatives are in an advisory role only (UNESCO 1972).

Every member state is obliged to submit a list of natural and/or cultural sites within its boundaries that may meet the criteria established by the convention that would permit the sites to be listed in the World Heritage List. The sites that are evaluated by the World Heritage Committee and added to the list are known as World Heritage Sites. The convention also made provision for the establishment of the World Heritage Fund. This is a trust fund that all member states are obliged to contribute to and can be used for various studies, provision of experts, training of staff, supply of equipment and the provision of low-interest or interest free loans relating to the objectives of the convention (UNESCO 1972).

ICCROM was established in Rome in 1959 after the 9th UNESCO General Conference in New Delhi in 1956. ICCROM has a world-wide mandate to promote the conservation of all types of cultural heritage (ICCROM Undated). ICCROM provides training, information, research, co-operation and advocacy with the aim of improving the professional conservation practice and raising the awareness of preserving cultural heritage (ICCROM Undated).

ICOMOS is an international non-governmental organisation of professionals, dedicated to the conservation of the world's historic monuments and sites (ICOMOS Undated). Many international standards in cultural and heritage conservation and management relevant to South Africa come from ICOMOS and ICCROM.

In South Africa, and in particular the province of KwaZulu-Natal, there are four relatively recent acts of legislation relevant to rock art. They are the National Monuments Act, 28 of 1969, the National Heritage Resources Act, 25 of 1999, the KwaZulu-Natal Heritage Act, 10 of 1997 and the World Heritage Convention Act, 49 of 1999.

Preceding these acts was a series of national legislations that have long since been superseded and are no longer relevant to this project. They were the Bushman Relics Protection Act of 1911. This act provided for the protection of archaeological objects and sites, including rock art. The Natural and Historical Monuments Act of 1923 followed and this act established the Historical Monuments Commission. In 1934 these Acts were replaced by the Natural and Historical Monuments, Relics and Antiques Act, which empowered the Commission to protect archaeological and palaeontological sites and objects, control the exportation of antiques and relics, as well as proclaim historical monuments and prohibit their alteration or destruction. (National Monuments Council 1998)

4.1.1 National Legislation

In 1969 the National Monuments Act (Act 28 of 1969) was promulgated in order to create the statutory body known as the National Monuments Council (NMC). The role of this body was stipulated as:

“to preserve and protect the historical and cultural heritage, to encourage and promote the preservation and protection of that heritage, and to co-ordinate all activities in connection with national monuments and cultural treasures in order that they will be retained as tokens of the past and may serve as an inspiration for the future.”

National Monuments Act (Act 28 of 1969)

The relevance of this act to rock art in KwaZulu-Natal is that the National Monuments Council vested custodianship of the rock art archive of, the then Natal, with the Natal Museum (Whitelaw 2004 pers.comm.). It is not clear at what date this occurred.

In 1999 the World Heritage Convention Act (Act 49 of 1999) was promulgated to:

“provide for the incorporation of the World Heritage Convention into South African law; the enforcement and implementation of the World Heritage Convention in South Africa; the recognition and establishment of World Heritage Sites; the establishment of Authorities and the granting of additional powers to existing organs of state; the powers and duties of such Authorities, especially those safeguarding the integrity of World Heritage Sites; where appropriate, the establishment of Boards and Executive Staff Components of the Authorities; integrated management plans over World Heritage Sites; land matters in relation to World Heritage Sites; financial, auditing and reporting controls over the Authorities; and to provide for incidental matters.”

World Heritage Convention Act (Act 49 of 1999)

With this Act in place the Ukhahlamba Drakensberg Park was added to the World Heritage List and proclaimed a world heritage site (WHS) in 2000. Ezemvelo KwaZulu-Natal Wildlife were appointed as the management authority of the site (UNESCO, Undated). As the criterion for the WHS proclamation was based on the rock art and the natural beauty of the area it is the responsibility of Ezemvelo KwaZulu-Natal Wildlife to design and implement management plans that incorporate the protection of this heritage.

In 1999 the National Heritage Resources Act (Act 25 of 1999) was promulgated with the following aim:

“To introduce an integrated and interactive system for the management of the national heritage resources; to promote good government at all levels, and empower civil society to nurture and conserve their heritage resources so that they may be bequeathed to future generations; to lay down general principles for governing heritage resources management throughout the Republic; to introduce an integrated system for the identification, assessment and management of the heritage resources of South Africa; to establish the South African Heritage Resources Agency together with its Council to co-ordinate and promote the management of heritage resources at national level; to set norms and maintain essential national standards for the management of heritage resources in the Republic and to protect heritage resources of national significance; to control the export of nationally significant heritage objects and the import into the Republic of cultural property illegally exported from foreign countries; to enable the provinces to establish heritage authorities which must adopt powers to protect and manage certain categories of heritage resources; to provide for the protection and management of conservation-worthy places and areas by local authorities; and to provide for matters connected therewith.”

National Heritage Resources Act (Act 25 of 1999)

As a result of this legislation the South African Heritage Resources Agency (SAHRA) was formed and is the national body that controls heritage matters. The council of SAHRA was appointed in the *Government Gazette*, 31 March 2000, Vol.417 No.21051, Notice No. R. 323 and consisted of nine members representing each provincial heritage authority of South Africa. If there was no provincial heritage authority established then a relevant official in the Provincial Directorate responsible for heritage would be nominated by the MEC. Other regulations that were passed were in *Government Gazette*, 2 June 2000, Vol.420 No.21239, Notice No.548, pertaining to SAHRA regulations and *Government Gazette*, 6 December 2002, Vol.450 No.24116, Notice No.1512, pertaining to the types of heritage objects requiring export permits.

4.1.2 Provincial Legislation

The provincial legislation pre-dates this national legislation with the 1997 KwaZulu-Natal Heritage Act (KwaZulu-Natal Heritage Act, 1997, Act No. 10 of 1997). This act created the body known as Amafa aKwaZulu-Natali (Heritage KwaZulu-Natal) and its aim is:

“To provide for the establishment of a statutory body to administer heritage conservation on behalf of the provincial government of KwaZulu-Natal, in particular the care for, maintenance, repair and management of historically important sites; architecturally important buildings; public monuments and memorials; military cemeteries and other important graves; traditional burial places; archaeological and palaeontological sites and artefacts; rock art; meteorites; historical shipwrecks, important cultural objects and trade therein, and the traditional building techniques of the people of the Province, by way of providing protections relevant to the type of site or artefact, and its relative significance; integration of protective measures into planning, development and local government systems and by providing for the establishment of educational, training, interpretive and tourism-related projects; and to provide for matters incidental hereto.”

KwaZulu-Natal Heritage Act, 1997 (Act No 10 of 1997)

The Natal Museum, to this day, considers itself the provincial custodians of the rock art of KwaZulu-Natal from the legacy of the National Monuments Council era and has grown an extensive database over many decades. This database consists of site locations, written records and visual material and it has collected this material since its inception in the early 1900's (Whitelaw 2004 pers. comm.). It has the human capacity and takes great pride in the investment of time and effort made in the maintenance of this database.

According to the KwaZulu-Natal Heritage Act, Amafa should own, maintain and secure such a database or at the very least have a duplicate of this database for its own record and management purposes. At present Amafa does not have any systems in place to do this effectively (van Ryneveld 2004 pers. comm.).

4.2 Rock Art Management and Conservation in the Ukhahlamba-Drakensberg Park

The value of rock art in the Ukhahlamba-Drakensberg Park as a cultural heritage asset to the nation has long been recognised (Pager 1971). Various initiatives have been implemented to establish guidelines and plans for the conservation and management of rock art sites. One of the earliest comprehensive efforts was by Mazel (1981) in which all the management units of the then Department of Forestry and the then Natal Parks Board were individually assessed. All known rock art sites in each unit were re-located if possible and ranked according to various criteria such as did they fall into the high intensity or low intensity use areas, the scientific significance of the site, accessibility, visibility, path network, vandalism and evidence of modern human occupation. Once the rankings had taken place various management requirements were suggested. One of the main suggestions was increased and focussed foot patrols to specific sites (Mazel 1981).

In 1998 a cultural resource management plan for the Natal Drakensberg Park was compiled (Wahl *et al.* 1998). Key points raised in this plan were a process of education and participation necessary to successfully implement any cultural management or conservation plan. The strategy of the management plan had three components, namely:

1. Conservation measures to curb the natural and unnatural deterioration of sites
2. The promotion of public and staff awareness to achieve greater appreciation of the value of the resources
3. The promotion and development of research opportunities, site recording and databases.

Implementation and maintenance of conservation measures included inventories being updated and computerised and standardisation of categories and an emphasis was made on the need for photography used to locate sites and monitoring deterioration in sites over time. Site vegetation and fire management were an issue and site interventions such as

removal of graffiti and bird nests etc. may be necessary on a site by site basis. It was also noted that there was a need for specific visitor management.

More recently Amafa have prepared a report and recommendations in a Cultural Heritage Audit for the uKhahlamba/Maloti Transfrontier Conservation and Development Area. Items raised in this report include the fact that rock art inventories are non-existent, incomplete and / or outdated and none are computerised (Amafa 1999). The adoption of international management policies is recommended. The lack of management capacity is identified as a major problem and the report also highlights the necessity of community education (Amafa 1999).

4.3 Case Studies

There are no apparent working examples of South African, or indeed African, web-based digital rock art or archaeological databases of any type available for viewing. It would be prudent to assess any projects that have attempted, or are, delivering a similar product over the world wide web. Such a case study serves to highlight current technology use and content delivery.

4.3.1 Northumberland Rock Art – Web Access to the Beckensall Archive

The ‘Web Access to Rock Art: the Beckensall Archive of Northumberland Rock Art’ project was created by the University of Newcastle Upon Tyne (UK) and went live to the public in 2004. Stan Beckensall spent 40 years finding and recording over 1000 rock carved panels estimated to date from 6000-3500 BP. Most of these panels are still to be found in the countryside of Northumberland which is situated in the north east of England. The welcome page of the website indicates that the intention of the site is to encourage greater enjoyment of the cultural resource displayed via images and information pertaining to each site. Another stated aim is to effectively manage and conserve this ancient rock art resource for future generations.

The main menu of the website contains the common elements such as Links, Help and FAQ, About Us and a Site Map. This case study will concentrate its investigation on the

other main menu items which are Browse Panels, Search Panels and InterACTIVE Zone. The main menu and welcome page are shown in figure 1.



Fig.1 The index page of the Northumberland Rock Art website. (Screen captured from <http://rockart.ncl.ac.uk/>)

Upon entry to the Browse Panels function of the website, one is presented with a menu of pre-sorted choices such as ‘would you like to browse all the panels, by individual parish, a map display, different panels types, etc.’ For example if one selects the option to browse by parish one is presented with a list of all the parishes that contain rock art. One would then select one of them and would then be presented with another sub-menu showing one all the rock art sites within that parish. One would then make an individual selection. The Browse Panels page is shown in figure 2.

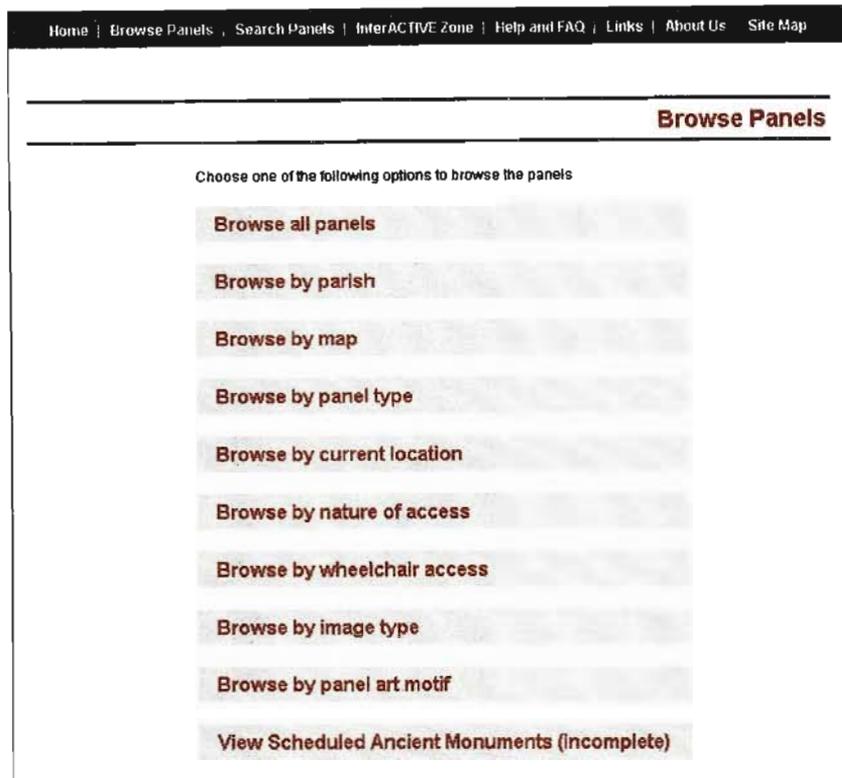


Fig.2 The Browse Panels page of the Northumberland Rock Art website. (Screen captured from <http://rockart.ncl.ac.uk/>)

The Search Panels function activates a program (Java Applet) that enables one to make a more selective search by choosing a number of different criteria that need to be met. A list of all the sites that meet all of ones chosen criteria is then displayed. The standard search options are Panel name, OS grid reference, Search radius, Panel type, Image type and General text. Three of the options offer a drop down selection box or the option to ignore them. Such a search would again proffer a list of available rock art sites that meet ones chosen set of search criteria. One would then make your individual viewing choice from that list. There is an option for an Advanced Search that offers a wider range of selection criteria. The Search Panel page is shown in figure 3.

Northumberland Rock Art
Web Access to the Beckensall Archive

Home | Browse Panels | Search Panels | InterACTIVE Zone | Help and FAQ | Links | About Us | Site Map

Panel Search

You can search our panels database using one or more of the following options. Alternatively you may use our [Advanced Search](#) facility for a wider range of criteria.

Search Criteria

Panel name

OS grid reference Search radius

Panel type

Image type

General text exact match

For exact match searches you may use * as a wildcard to look for multiple word endings in the General Search box. So 'carv*' would match both carved and carvings. Non exact searches automatically use wildcards at both the beginning and the end of each word.

Fig.3 The Panel Search page of the Northumberland Rock Art website. (Screen captured from <http://rockart.ncl.ac.uk/>)

Once one gets down to the individual site that one wishes to view, either by the route of Browse panel function or Search panel function, one is offered a standard list of data on each site. There is the General data that contains things like the current location of the site, which Parish the site occurs and an option to look at a detailed map showing the location of the site, what type of panel is it, legal status, nature of access, wheelchair access, general notes on the site and an indication in thumbnail form of what motifs are on the panel. Other main data options available for each individual site are Location, Archaeology, Environmental, Management and Images. If one selects to view images, one is presented with a list of images in thumbnail form from which an individual image can be selected and then enlarged if desired.

The InterACTIVE Zone is divided into four areas. They are Outreach, Learning Journeys, Out and About and Virtual Tour. In the Outreach section one can view video clips, listen to audio clips, view a behind the scenes story and view all the press coverage the project has obtained. In the Learning Journeys one can look at a photo gallery, view a bibliography or play games. The Out and About section contains educational information

on walking with rock art, conservation issues, photographic tips and an option to download a personal record sheet of visits to rock art sites. In the Virtual Tour section one can view a selection of sites for which a 3D 'Bubbleworld' has been created. Dedicated software is invoked within your web browser to view these 3D presentations. During this study this portion of the website failed for unknown reasons. There are also a selection of aerial photographs that may be viewed. The InterACTIVE Zone page is shown in figure 4.

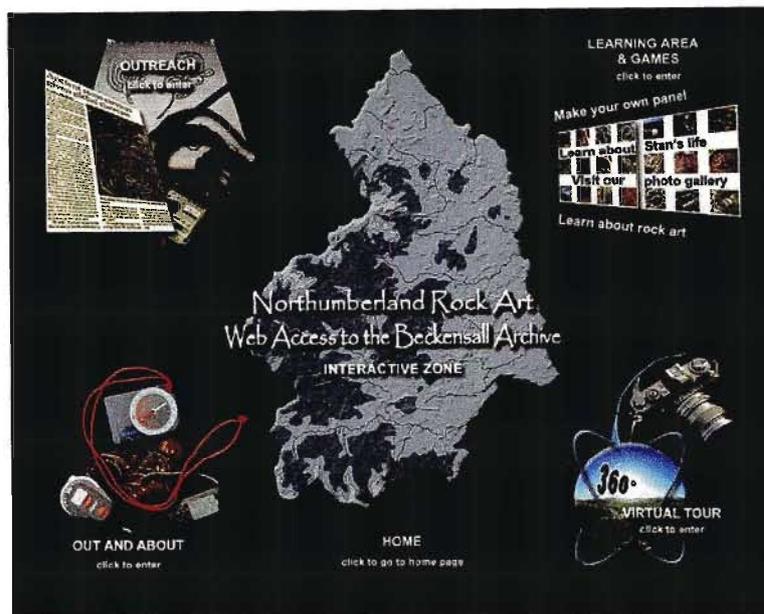


Fig.4 The InterACTIVE Zone page of the Northumberland Rock Art website. (Screen captured from <http://rockart.ncl.ac.uk/>)

It is obvious that this is a public website and it is dedicated to presenting a pre-accumulated rock art archive consisting of various aspects of data for general consumption. The layout and presentation of the website is of a very high standard and the navigation within the site is simple to understand and very effective in conveying its aims and objectives to the public. It is interesting and perhaps important to note that there does not seem to be any concern with protecting the site locations, on the contrary, there is an underlying invitation for the general public to appreciate this resource by visiting the sites in the field where possible.

4.3.2 The New Norwegian Rock Art Database

In 1996 the Directorate for Cultural Heritage on behalf of the Norwegian Ministry of the Environment initiated the web based digital database known as The Rock Art Project. Around 95% of Norway's rock art is damaged due to natural weathering, vandalism and other human impacts and the rate of deterioration is accelerating rapidly. Most of the art consists of rock carvings. The Norwegian Rock Art Database consists of photographs, drawings and maps, all in a digital format. The function of the database is to store a complete digital documentation of each site. The database is available through the world wide web to approved researchers, local and national government administrations only (Helliksen *et al.* Undated).

The front-end delivery system is a custom developed GIS that allows a selected site to be viewed on a background map. Data for each site consists of a text database linked to photographs, both of which are then linked to a detailed small scale topographic map or scaled tracing of the individual site. The custom application was developed using Visual Basic and Map Objects and designed for input and query using an Oracle database. The application is served over the internet by a Citrix application server. Both the Oracle and Citrix servers are resident on the same computer (Helliksen *et al.* Undated).

The application has a 100% execution on the server and only mouse clicks and screen updates are transmitted over the internet. The 'clients' or users of the data only need to download a small Citrix file that allows this type of interaction and thus bottom of the range desktop computers can be used for input or analysis of data. This type of structure is referred to as 'thin clients' and allows high performance over limited bandwidth connections such as ISDN and modems and is diagrammatically shown in figure 5 (Helliksen *et al.* Undated).

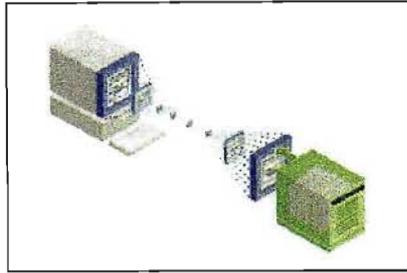


Fig.5 Example of Citrix thin clients where all operations are performed on the server and only results are sent to remote users. (Taken from Helliksen *et al.* Undated)

There are about 30 institutions that use this data consisting mainly of regional museums and government administration offices. These institutions are responsible for updating the central database which is physically located at the National Institute for Cultural Heritage (NIKU). Those institutions tasked to carry out updates of the database are given read-write access security passwords. Many of the fields in the database have detailed drop down menus so that input is standardised amongst the distributed institutions. NIKU offers training courses to all the operators within each institute that need to access the data (Helliksen *et al.* Undated).

The fact that this web-based rock art GIS is not available for the general public to view meant I could not access the site myself for the purpose of this case study and had to rely on a paper describing the rationale, setup and operational components. This project is a technical high order web database project aimed at institutions directly involved in the update, recording and management of these rock art sites.

4.4 Technology

A review of the background technologies involved in the development of a web based Geographical Information System (GIS) and the content it delivers is necessary as it is these advances that have made such an endeavour possible.

4.4.1 Geographical Information Systems (GIS)

Geographical Information Systems are computer based software or systems whereby spatial georeferenced data can be entered, stored, analysed and presented in various output formats (de By *et al.* 2001).

With regards to GIS, spatial georeferenced data refers to any kind of geographic phenomena that has a particular and unique position (spatial) that can be assigned to it and this position is described relative to the Earth's surface (georeferenced). There are many different types of georeferencing systems consisting of various transformation parameters, map projections and coordinate systems. A good GIS will offer the user an array of options in this regard and the user will choose the most suitable reference system for their application. It is necessary to note that within each individual user's application all the entered spatial data should have the same georeferencing parameters if there is to be any comparison or analysis between data sets (de By *et al.* 2001).

A GIS takes geographic phenomena in the real world into a simulated computer world. These computer representations are then acted upon by various applications to produce new visualizations representing the results of this manipulation.

4.4.2 Databases

A modern database is a computerized system for storing large amounts of data in an accessible format that can be accessed simultaneously, has a degree of data integrity and can be queried in various ways (de By *et al.* 2001). This computerized system is known as a Database Management System (DBMS) (Ferraz 2000).

A spatial database has all of the above characteristics but includes positional data (two or three dimensional) relating to the additional attributes describing the geographical phenomena. Within each database table there exist a number of rows or records known as tuples. Each record has a number of columns or fields and these are known as attributes. A relational database is one in which various attribute tables can be linked to one another through the use of a key identifier for each of those tables. Such a modern database can be extensively investigated or queried using a special language (software programme)

designed for this purpose (de By *et al.* 2001). One of the more common query languages is the Structured Query Language (SQL). SQL allows the user to generate simple to complex interrogation of one or more linked tables to generate a new table of the query result.

The contrast between a GIS and DBMS is that, in a GIS, one has spatial data with attribute tables that add a variety of descriptives to that spatial data. The strength of a GIS is that it is designed to analyse and manipulate spatial data through the use of in-built functions that specifically relate to various spatial phenomena (de By *et al.* 2001). In a project that involves large amount of spatial and attribute data it is often best to operate with a GIS and DBMS side by side. The GIS can access the data in a DBMS through inbuilt query language (often SQL) and present the results in a graphic medium which a stand alone DBMS cannot do.

This is particularly relevant to this project as each rock art site will have a large number of attribute tables of data associated with it. Numerous researchers and/or conservation managers may conduct a simultaneous query of the database using very different search criteria to achieve results pertaining to their particular field of expertise or job function. The results of these searches could then be subjected to further analysis of a graphic nature in the specialized realm of the GIS to produce a final result in a graphic format (Boehler and Heinz Undated).

4.4.3 The Internet and the World Wide Web

Having a deeper understanding of what is the Internet and the World Wide Web (WWW) and how it functions is necessary as this forms one of the key components of this project.

The internet is a global network of computers, or groups of computers, that have a means to exchange data of various types between them. When a group of computers is connected to each other in one location this is referred to as a Local Area Network (LAN). When one or more local area networks are connected to each other, normally over greater distances, this is referred to as a Wide Area Network (WAN). LAN's are normally

connected with special LAN cables while WAN's are normally connected to each other by telephone lines of various types (Strebe and Perkins 1997).

It was in 1969 that the Advanced Research Projects Agency (ARPA) of the USA Department of Defense (DoD) linked various universities and DoD research centres together. It was these research organizations that developed a standard set of protocols that would be used to exchange data via these WAN's. The suite of protocols that was developed was known as Transmission Control Protocol / Internet Protocol (TCP/IP) (Strebe and Perkins 1997).

Protocols define how computers communicate over a network. These communication protocols or rules determine when a computer can transmit data, when it must receive data, how to address data such that it arrives at the correct computer and what to do if there are any errors detected in the data.

The World Wide Web (WWW) was born out of the development of higher order internet protocols that allowed data to be exchanged and viewed graphically. These two protocols are HyperText Markup Language (HTML) and HyperText Transfer Protocol (HTTP) (Strebe and Perkins 1997). The result of these two protocols is what we know and view as Web pages. HTML is the base programming code used to construct web pages and HTTP is used to transfer web page documents from a web host to a web browser that decodes the HTML and presents the data in a visual form. All resources on the internet have a Uniform Resource Locator (URL) that relates to that specific type of resource. Every resource on the internet is hosted by a server. In order to locate the desired resource it needs to have an address that can be tracked over the internet. This addressing is referred to as the Internet Protocol (IP) address (Lammle *et al.* 1997).

4.4.4 Digital Imagery

Digital imagery is a core component of the RAMP and the growth in digital cameras and video cameras is as a result of the improvements in semiconductor sensors (Mikhail *et al.* 2001). A charge-coupled device (CCD) sensor consists of either a linear or two-dimensional area array of photosensitive pixels. When a pixel is struck by light electrons

are produced in amounts relative to the intensity of the light. These electrons are passed on to a well associated with that particular pixel. The position of the well can be changed by manipulating the clock voltage that acts on each pixel and in so doing move the packet of electrons along a shift register to eventually exit the sensor at an output terminal. The sequence of electrical output creates a waveform that can be displayed or digitized for later processing (Mikhail *et al.* 2001). This process is shown in figure 6.

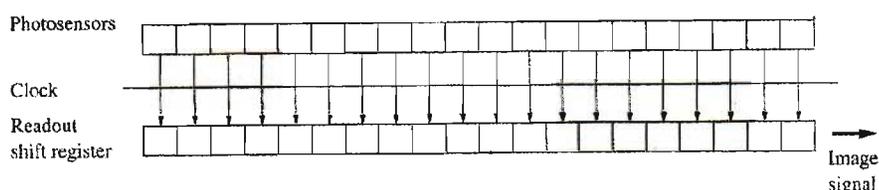


Fig.6 The construction of a linear CCD. (Taken from Mikhail *et al.* 2001: 53)

The pixel numbers and size determine the CCD chip characteristics. A chip with a greater number of pixels results in a potential higher resolution image (Mikhail *et al.* 2001). A 3CCD chip configuration in a stills camera or video camera results in a high quality image as there is one chip dedicated to each of the red, green and blue light bands as shown in figure 7.

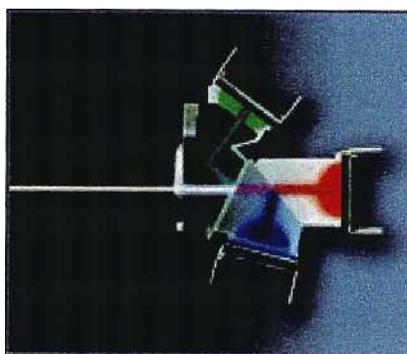


Fig.7 A typical 3CCD sensor configuration. (Taken from http://www.panasonic.com/consumer_electronics/camcorder/3ccd.asp)

4.4.5 Colour Charts – The IFRAO scale

The International Federation of Rock Art Organisations (IFRAO) first proposed a standard scale and colour chart for use in rock art photography in 1991 (Bednarik 1991) and its design was finalised in 1993. The scale colour chart is shown in figure 8.

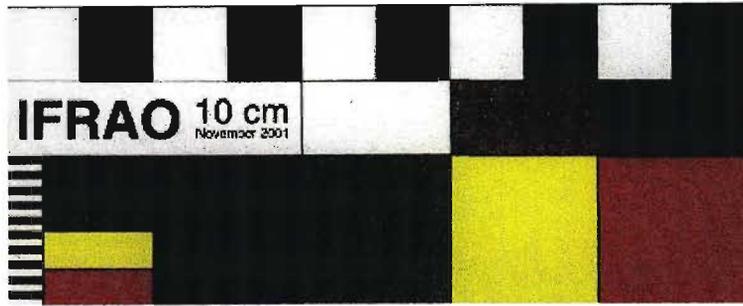


Fig.8 The international standard IFRAO scale showing four saturated colours and three grey scales.

The reason for the development of the colour chart was that it was realised that many hundreds of thousands of images of rock art had been captured on photographic negative and positive film over the decades. All of these medium are subject to deterioration over time. It was realised that if a standard colour chart was included in the images then there was a process of colour reconstruction that could take place. The scale chart is visible in the image in figure 9.

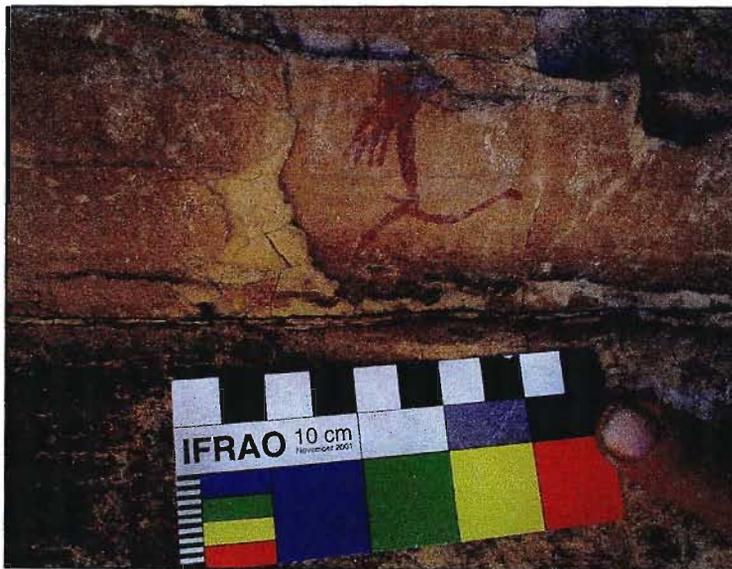


Fig.9 Image of rock art with IFRAO colour chart visible.

Forbes (2005 pers.comm.) states that the relationship between the colour in an image and the true colour of the rock art is dependent on a variety of influences and factors and this relationship is usually unknown and as a result the image is a distorted record of the art colour. As time sequential differences in images of the same site are used to monitor rates

of deterioration and vandalism (Wahl *et al.* 1998) it is important that there be a reference base on which the image colours can be reconstructed and thus compared.

The process of reconstruction is that a small number of pixels are chosen of one colour patch on the colour chart visible in the image. Each of the colours has a known value in the RGB (Red, Green & Blue) bands and the chosen sections values can be adjusted to the known value and that shift then applied to the remainder of the image. When this is done for all the colours on the chart the entire image should have been colour reconstructed. The problems with this, is that the known colour values are dependent on the original printing of the chart as well as its storage and use. Only having a limited number of colours in the chart also impacts on the reliability of the colour reconstitution (Forbes 2005 pers. comm.).

5. Conceptual Framework

Component B of this dissertation will investigate a practical case study of a small area within the Ukhahlamba-Drakensberg Park. This area contains a number of rock art sites as well as three newly discovered Dinosaur foot print sites. The case study approach will enable the acquisition of all datasets relevant to the development of a GIS to support management of archaeological sites in this area. The GIS will allow for positional and descriptive data about archaeological sites to be managed and visualized in an integrated environment. It will therefore be possible to click on the position of a site of interest on the spatial layer and corresponding details in form of text information, digital image and video displayed thus allowing the manager to assess the condition of the site. Conversely it should be possible to query the database for location(s) of sites that meet stipulated management criteria and such sites should be displayed. A GIS will allow for spatial analyses to be performed on the spatial datasets to enable further investigations such as identifying sites threatened by fire based on their location within uncontrolled burn areas available in the case study area.

Further benefits can accrue by distributing GIS data hosted on a single spatial server using the World Wide Web (WWW). Stakeholders can therefore query the database and perform simple analyses on-line from a remote computer. Where complex analyses are

required, relevant datasets can be downloaded so as to allow analysis on a local computer. This would enable the use of the same datasets by various authorised users to facilitate management and conservation decisions without duplication of resources.

Amafa (2005) has generated generic rock art management tables. These tables will be used to assess the functionality and capacity of a web-based GIS to deliver management and conservation decisions or support.

In addition to using the rock art management tables to indicate the possible effectiveness of a web-based GIS, questionnaires will be sent to relevant authorities in the field of rock art management and conservation with a request to test the developed web-based GIS on-line and provide feedback.

6. Methods and Data Collection

6.1 Compliance with Management Authorities

A project of this nature will have to work closely with various stakeholders, management authorities and abide by any relevant regulations. The three major stakeholders identified were the Natal Museum, Amafa and EKZNW.

The Natal Museum presently holds the rock art databases for KwaZulu-Natal. These databases consist of paper 1:50000 scale mapsheets with position information of every rock art site in their records. These sites are recorded by means of a dot made on the mapsheet at the approximate position of the site and a reference number unique to that mapsheet. The unique reference number corresponds with the sites paper written records as well as a new Microsoft Access database that has recently incorporated all the written records in electronic format (Whitelaw 2005 pers. comm.). In this project, GIS capabilities will enable the showing of positions of all the rock art sites by using coordinate data from the Natal Museum. The process necessary will be to obtain written support for the project through meetings as well as submission of the project proposal. The main issue of concern will be security of locational data on each site (Swart 2003

pers. comm.). It is anticipated that there will be operational procedures to deal with this issue.

Although the Natal Museum holds the most comprehensive database on rock art in KwaZulu-Natal and are considered the custodians of this data it is Amafa who are the legal and dominant authority concerning all aspects of rock art conservation and management in the province of KwaZulu-Natal. The provincial regulations dominate the national regulations in this case (van Ryneveld 2004 pers.comm.). The scope of the proposed project requires official permission from Amafa to proceed (KwaZulu-Natal Heritage Act, 1997, Act No. 10 of 1997) and the project proposal will be submitted to them for consideration before funding is applied for.

As this project will be working in the Ukhahlamba-Drakensberg Park which is managed by EKZNW the project will need to apply for a research permit to operate in the field. There is a standard application form that needs to be completed. It is proposed that permission for the project in principle be obtained before funding is sought. The standard application form is attached as appendix 1

6.2 Hardware and Software Requirements

The discussion involving hardware and software requirements will only pertain to the aspects of the project relevant to this dissertation and not the RAMP in general.

6.2.1 Hardware Requirements

The hardware requirements of the this aspect of the project involve the capture of digital imagery in the field by means of static images as well as videography for inclusion in the digital database. The RAMP proposes the use of two digital cameras, one for high resolution images for photogrammetry purposes and one for low resolution images for distribution over the internet where the size of the image is of great consequence. The high resolution camera proposed is a Fuji FinePix S2 Pro with a resolution of up to 12 Mega Pixels which results in each image being approximately 35 megabytes in size. The camera has 1 gigabyte SD memory cards and thus can store up to 28 images on each card

at full resolution. The second camera proposed is a Fuji FinePix A210 with a resolution of 3.2 Mega Pixels which results in each image being approximately 1 megabyte in size. This camera has a 128 megabyte storage card and thus can store approximately 128 images at full resolution.

The videography on the project will be captured using a Canon XL1s broadcast quality digital video camera. The camera contains a 3CCD chip and captures the video onto a mini Digital Video (DV) tape from which the captured data can be downloaded to a PC and manipulated using standard software such as Windows Movie Maker[®].

Additional hardware is required to store and distribute the data and for this purpose a high specification computer to act as a server is required. The particular technical specifications of the server should be the best at the time of purchase (Helliksen *et al.* Undated) and it is proposed that the following be the minimum main specifications of the server:

- A high speed processor (Pentium 4)
- 1 or 2 gigabytes of Random Access Memory (RAM)
- A 128 megabyte graphics card
- 3 or 4 large capacity (120 gigabyte) hard disk drives
- A dual layer DVD writer for backups

As this server will store the entire digital database, including imagery, as well as manage the software to distribute the data via the internet it is important that it has the capacity to protect this data from loss through hard drive failure. In order to achieve this, the hard drives will be installed in a mirrored or striped RAID configuration (Strebe *et al.* 1997). This installation technique allows data to be spread or repeated over a number of hard drives. Should an individual hard drive fail then it can be physically removed and replaced with a new hard drive and the lost data rebuilt on the new hard drive.

6.2.2 Software Requirements and Functioning Role

The software requirements for this project relate to the operation of the server and the connection and distribution of data over the internet. The software choices will be limited

to the available software licenses of the University of KwaZulu-Natal. The computer operating system will be Microsoft Windows XP Professional®. The standard Microsoft Office Professional® suite of programs will be installed, the key component being Microsoft Access® as we will be using an Access database in the background. Internet Information Server (IIS) is a standard component of the operating software which can be activated if the PC is permanently connected to the internet. This will allow anyone who knows the IP address, or domain name linked to the PC's IP address, to be served a website with the content of choice and construction. Microsoft Frontpage will be the webpage authoring software that will be used to create this website served by IIS. The Environmental Systems Research Institute (ESRI) ArcGIS® 9 desktop Geographical Information System (GIS) software will be installed to manipulate particular datasets before final authoring in ESRI ArcIMS® 9.

The ArcIMS® 9 software package is the core of the web GIS delivery system and as such needs to be discussed in some detail. The sole purpose of this software is to publish maps, data and metadata on the web. Figure 10 shows the multitier architecture of the system (ESRI 2004).

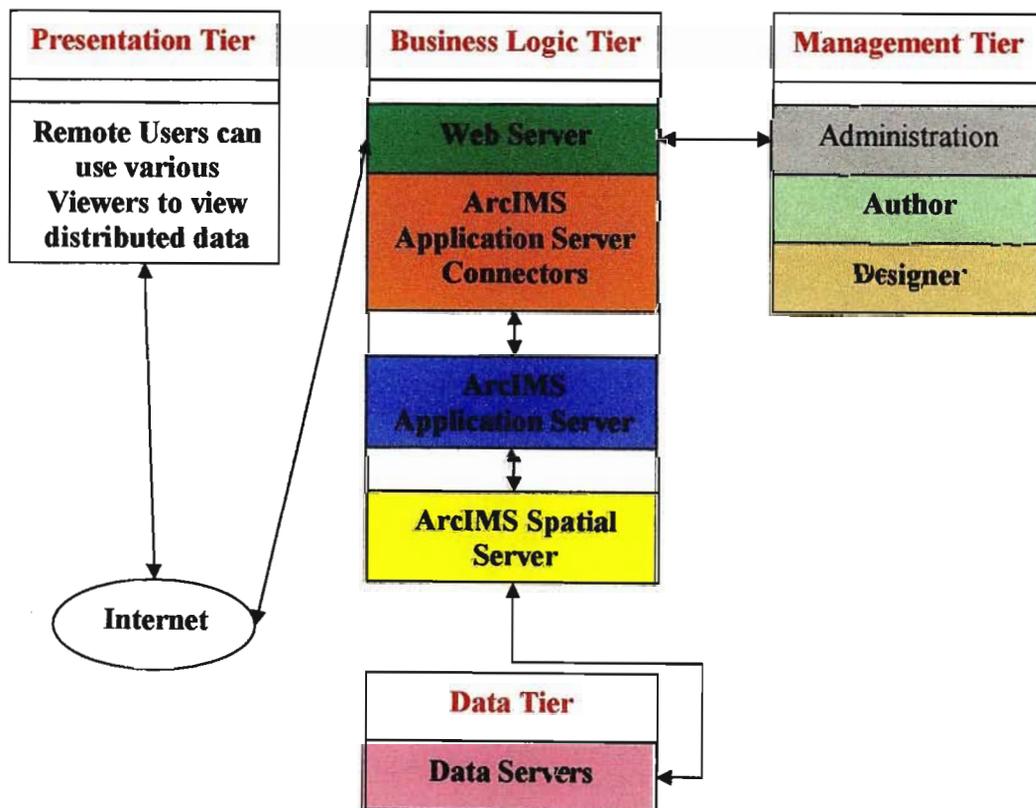
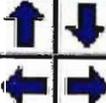


Fig. 10 Graphical representation of the ArcIMS® 9 multitier architecture. (Taken from ESRI 2004)

The various tiers are the Data Tier, ArcIMS® Management Tier, Business Logic Tier and the Presentation Tier.

The Data Tier contains all the source data which is accessed by the Business Logic Tier for presentation over the web. It is proposed that data sets such as the Microsoft Access® Database, all the individual ArcGIS® datasets and any other data sets needed for the project will reside in this tier.

The ArcIMS® Management Tier will access these raw data sets and design and author the maps that will be presented over the web. The design function in this tier allows the administrator of the software to determine the analytical functions that will be displayed with the maps so that a remote user can manipulate the data. Figure 11 shows an example of the toolbar buttons and an explanation of their function as created in the Designer module of the Management Tier.

Icon	Tool Name	Tool Use
	Toggle	Toggle between Legend and Layer List
	Toggle	Toggle overview map
	Zoom In	Zoom In
	Zoom Out	Zoom Out
	Zoom to Full Extent	Zoom out to full extent of map
	Zoom to Active Layer	Zoom to extent of the active layer
	Back to Last Extent	Zoom back to last extent
	Pan	Click and drag to move over map
	Pan by Aspect	Pans North, South, West and East
	Hyperlink	Click on feature of active layer to hyperlink to new document
	Identify	Click on feature of active layer and attributes open in bottom window
	Query	Query attribute table of active layer
	Find	Find feature by name
	Measure	Use to measure distance between features
	Set Units	Sets the units of measure on the screen
	Buffer	Can create a buffer around a feature/s by distance

	Select by Rectangle	Draw a rectangle around feature/s to select them
	Select by Line/Polygon	Select features by use of lines or polygons
	Clear Selection	Clears all previous selections
	Print	Prints map as per the present screen view

Fig. 11 An example of the available tools and their function selected during the design of a map.

It is important to note that each map created normally consists of various GIS datasets that may be manipulated in the same way as a desktop GIS system. On each map designed a different selection of tools can be added for display with the map data. This allows the administrator to restrict or enhance the remote users ability to manipulate the data. The Authoring module in the tier lets the administrator select which GIS datasets to incorporate into the final map presentation. These completed maps are then stored in the ArcIMS Spatial Server ready for access within the Business Logic Tier on demand.

The Presentation Tier represents how the remote user will access, view and interact with the designed and authored maps that are stored in the ArcIMS[®] Spatial Server. The remote user can use a variety of clients to access the data over the internet. ArcIMS[®] Viewers are built into the ArcIMS[®] software and are created in the design stage of each map. When a remote user uses the system for the first time they are required to download the ArcIMS[®] Viewer which runs on a Java platform. ArcMap[®] can also be used as a client to access, view and manipulate ArcIMS[®] maps.

The Business Logic Tier handles requests for data from the Presentation Tier. The architecture of the Business Logic Tier is shown in figure 12.

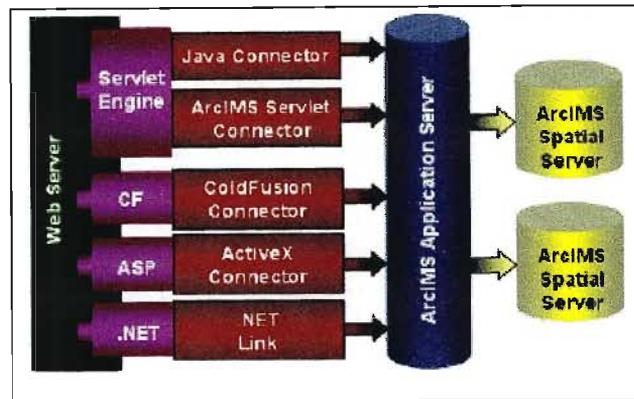


Fig. 12 A graphical representation of the Business Logic Tier. (Taken from ESRI 2004)

A request by a remote client is passed over the internet to the web server. Depending on what client was used to make the request the web server will then pass the request to the relevant application connector. The application connector converts all requests, no matter what connector is used, into ArcXML[®] which is a language that the ArcIMS[®] Application Server understands. The Application Servers role is to manage the retrieval and assembly of data from the ArcIMS[®] Spatial Servers.

The ArcIMS[®] Spatial Servers are the core of the system. They are compiled of seven server types namely, Image, Feature, Query, Geocode, Extract, Metadata and ArcMap[®] servers.

6.3 Database Design, Inter-relationships and GIS Datasets

As this project intends to present various datasets via a web-based GIS front-end system in such a way that management decisions can be made by various role-players it is necessary to investigate the separate data components that, when integrated, will make up the system.

6.3.1 Database Structure

A database is described by Howe (1989) as a collection of non redundant data that is sharable between different application systems. The core of this project is the digital database that will be developed to serve as an archival, research and management tool and

the application systems that will access this database will be a desktop GIS, a web-based GIS as well as a stand-alone interface as part of the database itself.

In developing a database for rock art purposes one has to consider the minimum standards set by the South African Rock Art Data Archive (SARADA) which had been agreed to by all South Africa's museum curators and universities (Pearce 2005 pers.comm.) SARADA is an initiative of the Rock Art Research Institute (RARI) of the University of the Witwatersrand, South Africa.

In order to generate a start point from which to begin the design process it is proposed that the RAMP's two archaeologists draw up a basic structure and an expansive list of data entry fields. Their brief will be based on the fact that a vast amount of energy, time and funds would be expended on reaching and documenting a site and thus the documentation should be as all inclusive as possible. The Natal Museum has completed the capture of all their paper documentation onto a Microsoft Access database of their own design that replicated the paper classifications of their documentation records. It was felt that the existing level of documentation in their database was inadequate for the purpose of this project. It is proposed that the database encompass as many rock art classifications as possible. Additional rationale for the expanded number of fields is that by not including the greatest choice possible the database would be limiting the direction or needs of particular rock art researchers or managers now and into the future.

David Pearce advocates an avoidance of classification of rock art imagery as this is a very subjective process (Pearce 2005 pers.comm.). Without clearly defined boundaries there are many instances when the issue becomes entirely subjective and to be avoided if possible. He also states that should an enlarged database with expanded categorisation take place then categories would need to be chosen with a purpose in mind, preferably relating to the conservation and management of the site (Pearce 2005 pers.comm.).

This viewpoint is acknowledged but it is felt that a strictly objective classification system could paralyse possible future needs of researchers and extensive discussions will be needed to establish a structure and content that would allow individual documenters to progress as far as their own abilities and confidence would permit, while at the same time trying to incorporate as much objectivity as possible. It must be remembered that as

digital imagery is proposed as an integral part of the database that any subjective input by one documenter could easily be corroborated or challenged by another by analysing the imagery and drawing new conclusions. This facility has not been available to date without extensive hardcopy archival retrieval and viewing by manual means (Swart 2004 pers.comm.).

The SARADA minimum standards for a digital archive needed to be investigated in more detail before structuring of the database can take place. The standards include compulsory fields as well as recommended fields of data. These standards and requirements are listed below.

- **SITE NAME:** Sites must be named according to the registered farm name as they appear on the 1:50 000 map series of South Africa. If there happens to be more than one site on the same registered farm, it should be named numerically in roman numerals i.e. Holkrans I; Holkrans II; Holkrans III. Each site should be checked on the respective maps to make sure that the correct names are used and also to ensure that the spelling of these sites are exactly as they appear on the maps.
- **ALTERNATIVE SITE NAME:** Often researchers have used the homestead name and not the registered farm name to record sites. [Homestead names are the names of the subdivisions of the registered farm and is often indicated on the 1:50 000 maps to show where homesteads are located on a particular farm]. These homestead names should be recorded as **alternative site names** and indicated as such along with any other names that might have been ascribed to the site that does not match the registered farm name. The registered farm name will become the valid name for these sites.
- **SITE ID:** The SARADA digitizing team will ascribe a seven digit code to each of these sites i.e. RSA BLL1 - RSA (indicating the country in which the site is found); BLL (a three digit abbreviation of the registered farm name, in this case Ballloch); 1 (indicating the number of the site; this is useful when there are more than one site on the same farm – see section under site name) These site codes will be used to link further information pertaining to a particular site to the site record on the database (See section on slides). It is also used to identify sites on the public version of the website. Please note that this will be done by the digitizing team and need not be done by the individual institutions!
- **LOCATION:** It is important that each site will have the following location information: Country, Province, and District. These should be checked against the 1:250 000 map series to make sure that the farm falls within the correct district borders.
- **SITE COORDINATES:** This is the longitude and latitude information for the location of the site. This is not a required field but please indicate it if the data is available. Ideally each site should be plotted on the relevant 1:50 000 map but this is not a necessity if the information is not available.
- **NEAREST TOWN:** It would be advisable to record the nearest town where possible but not a requirement. The information for this can be checked on the 1:50 000 and 1:250 000 maps while checking site names and districts.
- **MAP SHEET:** Each site must have the number of the 1:50 000 map sheet on which it is located.
- **OWNER:** This is the name and contact details of the landowner for the property on which the site is located or contact detail for the community or authority responsible for the rock art site. This field is not a requirement but please indicate the information where available.
- **HOW TO FIND THE SITE:** This is a short description of how the site can be found. This is not a required field but please indicate this if the information is available.
- **TECHNIQUE:** Please indicate whether the site is a painting or engraving site.
- **BRIEF DESCRIPTION OF THE ART:** This is a short description of the site and what the art looks like. This is not a required field but please indicate the information if this is available.
- **PERSONS WHO HAVE VISITED THE SITE:** this is a list of people who has been to the site and the dates on which they visited the sites. This is not a required field but please indicate if the data is available.

SARADA minimum criteria for site information

With these standards in mind the new database structure and content can be designed. It also needs to be stated that the intention is to have this database operate on a stand-alone basis as well as serve as the source data for the desktop GIS and the web-based GIS. In its stand-alone role it is anticipated that various users may not be proficient with the use or query of databases and will endeavour to develop a user friendly interface that automates the anticipated common use of the database.

It is proposed that when the database is activated from an icon on the desktop the user is presented with a menu that offers the user the choice of capturing a new site, viewing a captured site, editing a site, proceeding to a reports page or closing the database.

It is anticipated that the capturing, viewing or editing option would produce the same form but with different controls. Capturing would indicate that the operator was adding a new record to the database. Viewing would indicate that no changes could be made to any records and editing would indicate that changes could be made to existing records. This initial form would contain many of the minimum requirements of SARADA. It is anticipated that on this first form there would be a number of additional tabs that when selected would take the operator to a new table of input for a specific category. These categories would be a more detailed description of the rock art, a description of paintings that fall into the classification of animals, a description of paintings that fall into the classification of symbolic figures, a description of paintings that fall into the classification of human figures, a description of paintings that fall into the classification of plants, a description of paintings that fall into the classification of objects and structures, a general description that would include numbers and positions of all paintings on a panel as per the normal site description techniques used by museums, a form that allows for the imagery manipulation as well as a management form that describes a variety of criteria used in the conservation and management assessment of a site. It is anticipated that there will be a report tab that would produce a report specific to the site being viewed.

It is planned that the design incorporates all the fields that were used by the Natal Museum to convert their paper records into their Microsoft Access® database. An example of a paper site record is attached as appendix 2. This will enable the importation of all the existing site data that they had expended a great deal of time and effort and

funds on capturing. As far as individual fields go the Natal Museum database has 31 fields relating to rock art and initial planning would indicate that the RAMP database would have approximately 400 fields. As one can see the proposed RAMP database could contain the possibility of twelve times more data fields than the original. The database fields will be structured in such a way that the category options within each form would offer the documenter the opportunity to be very objective i.e. not choose to fill in that form, or be a combination of objective and subjective and choose a broad category description or to be subjective and fill in more descriptive options available. An example of the proposed format is shown in figure 13 and it is clear that a documenter can choose to describe an image as just an antelope or can go deeper into the form and make the more subjective selection from the list provided or enter a written comment.

Fig.13 The proposed form entry format that allows documenters different levels of entry based on their own capabilities of identification and categorisation.

6.3.2 Data Inter-relationships

It is proposed that the database will be a relational database constructed from eleven tables. It is planned that the main table be named the MainSite and that it would contain the main SARADA components. It is proposed that this table would be linked to nine other tables that would be constructed according to the categories matching the main tabs in the database. They could be named RockArt, Animal, HumanMen, RitualBeingWaterSpirit, Plant, ObjectStructure, DetailSiteDescription, SitePicture and Management. This structure focuses the documenters efforts into those categories in the field and in data input into the database. The figure below indicates the proposed relationships between the MainSite table and the other linked tables which will be 1 to 1 relationships except for the SitePicture table which is a 1 to Many relationship due to the possible large number of images that could be entered for each site. Shown in figure 14 is the proposed table format showing the relationships between tables.

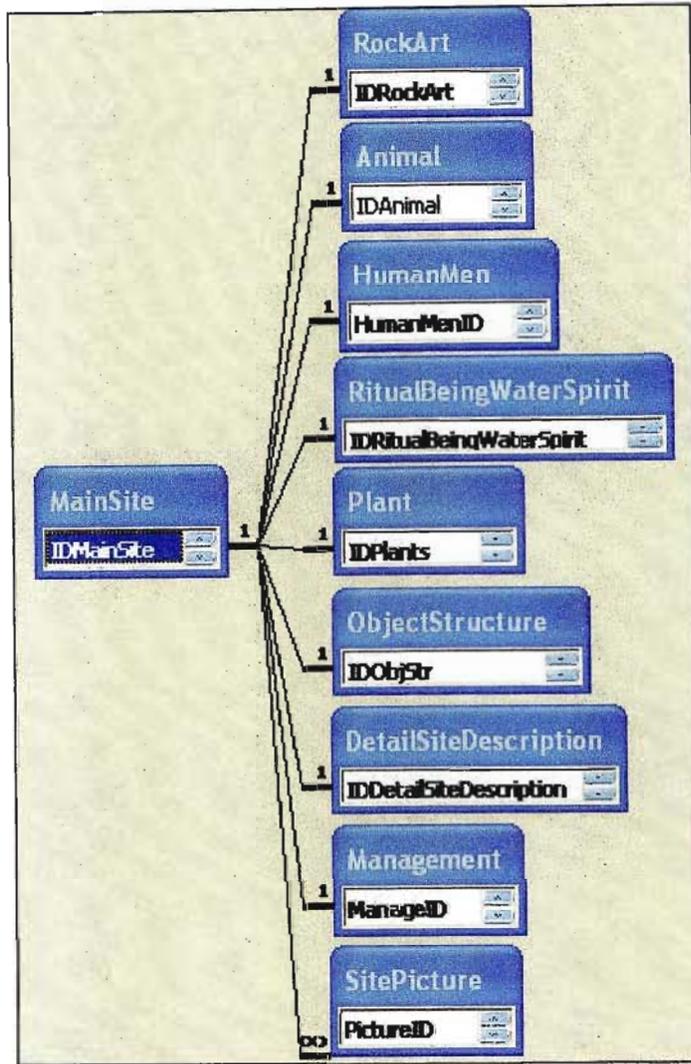


Fig.14 Proposed database tables and relationships.

6.3.3 GIS Datasets and Referencing System

Both the desktop and web-based GIS systems would require background datasets. The most useful of these would be digital 1:10 000 scale black & white (or colour) rectified aerial photographs. These are available from a number of sources such as aerial survey companies and the Department of Land Affairs. Each individual image covers approximately 5,5 km's by 5,5 km's on the ground. All the images would have to be mozaiced to merge together seamlessly and have been georeferenced using the Gauss Conform Projection. This projection is based on using 2° belts of longitude with the odd degrees of longitude being the central meridian for each set. In the case of the Drakensberg this would mean using the 29° line of longitude as the central meridian. The Global Positioning System (GPS) constellation of orbiting satellites is used to obtain a

coordinate in the World Geographic System 1984 (WGS84) reference datum and is then projected using the Gauss Conform Projection resulting in a coordinate in WG29. WG29 reflects coordinates in y and x instead of showing coordinates in degrees, minutes and seconds of latitude and longitude. The y coordinate being indicated in metres from the central meridian of 29° longitude, increasing to the West with 0 being on the central meridian. The x coordinate is indicated in metres positively from the equator southwards.

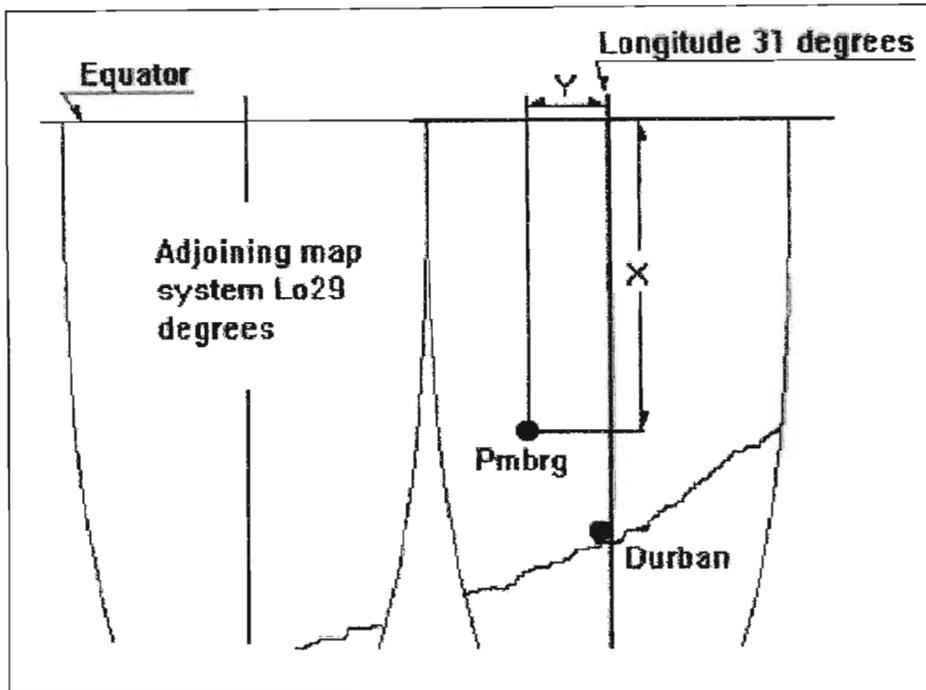


Fig.15 Example of the 2° Gauss Conform Projection (Taken from Jackson 2004)

There will have to be a field in the database that allows the entry of these coordinates as well as the normal WGS84 degrees, minutes and seconds of longitude and latitude. This will be necessary so that a data layer can be created from the database that shows each site location as a point in the GIS using the same datum (WG29) as the other data layers such as the background aerial imagery. This GIS data layer will be created from the MainSiteTable where these coordinates are entered in the database so that the GIS layer is linked to this table and is indicated in the GIS as the main attribute table for each site position.

Other datasets of interest to this project would be the boundary of the conservation area, situation of local communities, hiking paths, rivers and streams, water points, public

parking areas, roads, campsites, unplanned burned areas and planned firebreaks. All of these datasets would need to be georeferenced using the WG29 datum in order to correctly perform analysis between them.

6.4 Field Data Collection

A document will be produced in a format that replicates the fields used in the electronic database. This will enable fieldworkers to print a suitable number of copies of this document before heading out into the field on documentation expeditions. The relevant fields will be selected and completed manually in the field before data entry into the electronic version of the database in the office. The paper copies will be filed for future cross referencing and archival purposes. An example page of such a document is attached as appendix 3. Ideally capture of the field data should be done directly into an electronic version of the database and various options will be investigated.

The still imagery that is proposed as a key component of the database requires that a general site identification image be taken, showing the entire site as one would see it when approached on foot. This will be to aid in the relocation of the site in the field should that be necessary. All individual or groups of paintings will be photographed with the IFRAO colour and scale bar included in the image. One of these images will be selected as the key image which will be included on the MainSiteTable form. This key image is the image that is the most prominent image in the site to aid in the verification of site location on subsequent site visits. An example of these two images at a site is shown in figure 16.

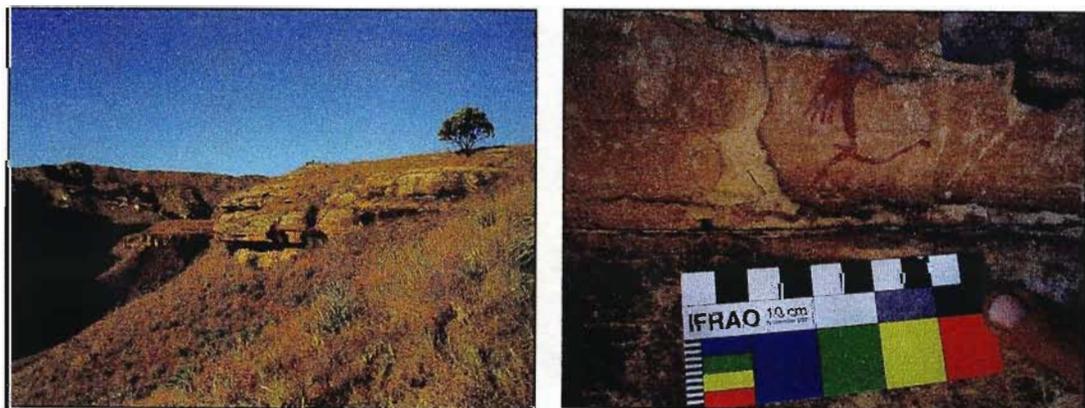


Fig.16 Two images showing site location and the most prominent image in the site.

An attempt to include video imagery into the database will be made. It is proposed that this imagery will consist of 360° panoramas that will start with close up imagery of the rock art panels and then sweep out of the site to show the aspect and environment in which the site is situated. This will be done from two points (or more) in the site so that experimentation with videogrammetry can take place at a later date. Videogrammetry is a new technology that proposes to generate maps from imagery captured by video from two or more different stations of the same target area similar to the normal process of making maps using photogrammetrical techniques. Photogrammetry is the process of deriving metric information from photographs which involves the elimination of scale distortions present in individual photographs (Mikhail *et al.* 2001).

7. Application

As indicated in the conceptual framework, Component B of this dissertation will investigate a practical case study of a small area within the Ukhahlamba-Drakensberg Park. In this area there will be a number of rock art sites as well as three newly discovered Dinosaur footprint sites. As a result of this rare find and the combination of rock art and Dinosaur footprints this area may become of greater visitor interest and require a specific management plan.

The web-based GIS will be used to illustrate the capabilities of such a system in assisting in the management of such an area and will be assessed using generic rock art management tables.

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A web-based GIS as a management tool for rock art sites in the uKhahlamba-Drakensberg Park

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ABSTRACT

The importance of managing and conserving cultural heritage can not be overemphasised. It is this realisation that has prompted the United Nations Educational, Scientific and Cultural Organisation to declare identified sites of cultural importance as World Heritage Sites. The uKhahlamba-Drakensberg Park (UDP) was declared such a site in 2000, with its natural properties and cultural heritage as the criteria for inscription. The cultural heritage centres on the vast quantity of rock art that is renowned for its quality and diversity of subject. It is an important consideration for future generations to have the opportunity to view and understand this rich history and culture. There are increasing human and natural impacts on this non-renewable resource and to minimise these impacts and thus ensure the longevity of the resource it is necessary to develop a multi faceted selection of management and conservation tools. This realisation led the Programme of Geomatics, University of KwaZulu-Natal to conceptualise a project to develop a web-based Geographical Information System (GIS) specifically aimed at assisting in the management and conservation of rock art sites for the Valley of Pools in the Cathedral Peak Conservation Area of the UDP. Data for the project was captured in the field using Global Positioning System (GPS), digital camera and video camera as well as conventional hardcopy documentation. Existing digital spatial data and descriptive data were also collected from relevant stakeholders and a commercial organization. A pilot spatial database was then developed using ArcGIS®9 and Microsoft Access®, and later tested using a set of integrated simulated queries reflective of routine questions that users may request. Upon obtaining satisfactory responses to the queries, the integrated database was migrated and authored in ArcIMS®9 where it was further tested, and subsequently access was given to selected external professionals, both nationally and internationally, from various backgrounds, for evaluation purposes. Feedback from this process was favourably obtained.

INTRODUCTION

The Rock Art Mapping Project (RAMP) is a major multi faceted rock art documentation and distribution project conceived and implemented by the Programme of Geomatics (Land Surveying), Howard College Campus, University of KwaZulu-Natal, South Africa. RAMP received funding from the South African National Lotteries Distribution Trust Fund (NLDTF) in July 2003 and one of the objectives of the project was to create a web-based Geographical Information System (GIS) for researchers and managers which would record, inter alia, the condition and location of each site as well as provide an accurate source of mapping data that can be used for research and management purposes. A case study of the Valley of Pools area, which is a small section of the Cathedral Peak Conservation Area, in the uKhahlamba-Drakensberg Park was chosen to base the investigation of a web-based GIS as a management tool for rock art sites.

The Natal Museum is considered the official provincial custodian of the rock art data set for KwaZulu-Natal. The Natal Museum has recently completed the conversion of its paper documentation library into a digital database (Whitelaw 2005 pers.comm.). The present spatial archive consists of a set of 1:50000 scale paper mapsheets that shows the location of rock art sites with the presence of a dot and a unique reference number written on the mapsheet. This unique reference number is used to reference a paper filing catalogue system where the written records and documentation on each site is kept. Should there be any visual documentation on a site such as photos (black and white or colour), tracings or slide transparencies, their location in a fire resistant strong-room is indicated in the written record (Swart 2004 pers. comm.). Should a researcher wish to access any of this data he or she has to proceed through a physical process that is time consuming, elaborate and a danger to the actual archive should any of this material be damaged or lost while in the custody of the researcher. The new digital database of the written record still refers to lengthy texts in these documents where necessary. The database was constructed to include all of the fields that were present on the written recording sheets.

Amafa aKwaZulu-Natali (Amafa) are the legal managers and conservators of the archaeological heritage in KwaZulu-Natal (KwaZulu-Natal Heritage Act, 1997, Act No. 10 of 1997). At present they do not hold any hard copy material on rock art sites and rely

entirely on the Natal Museum and their long history of archival and recording of rock art (van Ryneveld 2004 pers.comm.). At present any management or conservation effort involves field investigations on a case by case basis (Wintjes 2005 pers.comm.).

With the advent of the internet or world wide web (www) and the proliferation of hardware and software technology in the 1990's it is now possible to collate various datasets in the form of a Geographic Information System (GIS) and serve this vast array of digital, spatially georeferenced data to relevant managers who can then use this tool to analyse and base management decisions on the available data.

ROCK ART CONSERVATION AND MANAGEMENT IN THE UKHAHLAMBA – DRAKENSBERG PARK

The value of rock art in the uKhahlamba-Drakensberg Park as a cultural heritage asset to the nation has long been recognised (Pager 1971). Various initiatives have been implemented to establish guidelines and plans for the conservation and management of rock art sites. One of the earliest comprehensive efforts was by Mazel (1981) in which all the management units of the then Department of Forestry and the then Natal Parks Board were individually assessed. All known rock art sites in each unit were re-located if possible and ranked according to various criteria such as whether they fell into the high intensity or low intensity use areas, the scientific significance of the site, accessibility, visibility, path network, vandalism and evidence of modern human occupation. Once the rankings had taken place various management requirements were suggested. One of the main suggestions was increased and focussed foot patrols to specific sites (Mazel 1981).

In 1998 a cultural resource management plan for the Natal Drakensberg Park was compiled (Wahl *et al.* 1998). Key points raised in this plan were a process of education and participation necessary to successfully implement any cultural management or conservation plan. The strategy of the management plan had three components, namely:

4. Conservation measures to curb the natural and unnatural deterioration of sites
5. The promotion of public and staff awareness to achieve greater appreciation of the value of the resources

6. The promotion and development of research opportunities, site recording and databases.

Implementation and maintenance of conservation measures included inventories being updated and computerised and standardisation of categories and an emphasis was made on the need for photography used to locate sites and monitoring deterioration in sites over time. Site vegetation and fire management were an issue and site interventions such as removal of graffiti and bird nests etc. may be necessary on a site by site basis. It was also noted that there was a need for specific visitor management.

Amafa prepared a report and recommendations in a Cultural Heritage Audit for the uKhahlamba/Maloti Transfrontier Conservation and Development Area. Items raised in this report include the fact that rock art inventories are non-existent, incomplete and / or outdated and none are computerised (Amafa 1999). The adoption of international management policies is recommended. The lack of management capacity is identified as a major problem and the report also highlights the necessity of community education (Amafa 1999).

More recently there has been a move to formalise and standardise the management of rock art sites by inclusion in Integrated Management Plans (IMP). Examples of these can be seen from the Matobo Hills World Heritage Site IMP (2004) and the Vhembe/Dongola National Park IMP (2003) where generic rock art management tables have been presented.

In figure 1 a generic heritage planning process (SARAP 2005) is shown.

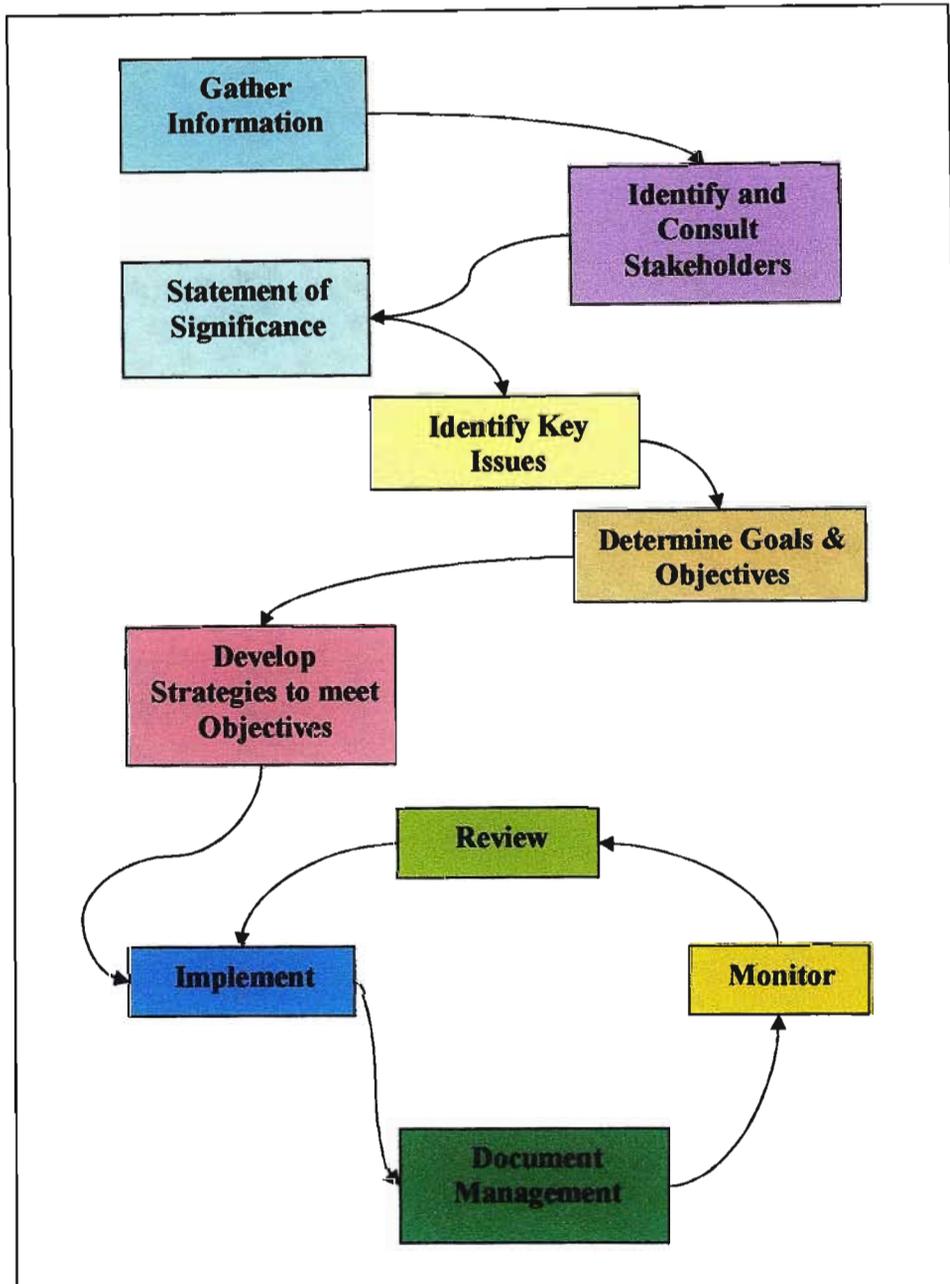


Fig.1. A heritage management planning process (taken from SARAP 2005)

This process was highlighted at the Mapungubwe Rock Art Site Management Workshop 2005 (SARAI 2005) with a step by step process as follows:

- Step 1: Identifying interests and gathering information
- Step 2: Determining the significance of the site
- Step 3: Identifying key issues
- Step 4: Determining goals and objectives for management
- Step 6: Implementation and review

Step 7: Documenting management

Amafa (2005) has recently begun work on preparing generic cultural resource management plans for the uKhahlamba-Drakensberg Park. This planning takes the form of tables with each table addressing a particular aspect of management and the key issues regarding that aspect of management. These tables and their corresponding key issues will be used to evaluate the potential of the web-based GIS in the results of this paper.

MATERIALS & METHODS

There were various elements relating to materials and methods due to the varied scope of the project involving field data collection, hardware setup and use, software setup and use as well as data origination, manipulation and preparation. All of these components are needed to ensure a successful implementation of the web-based GIS.

Compliance with Management Authorities

A project of the magnitude of RAMP needed the support of various stakeholders. The main stakeholders were identified as the Natal Museum, Amafa and Ezemvelo KwaZulu-Natal Wildlife (EKZNW). Support for the project was obtained from the Natal Museum and Amafa and a project number (DR/030/03) was issued by EKZNW.

Hardware Requirements

The hardware requirements of this aspect of the project involved capture of digital imagery in the field by means of static images as well as videography for inclusion in the digital database. Although RAMP has a high resolution professional digital camera and a broadcast quality digital video camera it would have resulted in redundant capture as all digital data had to be optimised for delivery over the internet. Instead a Fuji FinePix A210 with a resolution of 3.2 Mega Pixels was used for the still image capture. This resulted in each image being approximately one megabyte in size which necessitated optimisation down to approximately 40 kilobytes in size for the internet. The videography for the project captured using a JVC GR-DVL300 digital video camera with data stored on a mini-DV tape. It was found that approximately one minute of field capture resulted in approximately five megabyte file sizes. This was deemed the maximum that remote users would be prepared to download and view. It was felt that any larger and the risk would be that this component of the GIS would not be investigated. A Garmin eTrex Global Positioning System (GPS) unit was used to record site positions. Such a handheld GPS

unit records horizontal positional information generally within a 5m-10m accuracy while elevation is less accurate and was not considered important for this project. Sub-centimetre accuracies in horizontal and vertical planes will be achieved using a high order differential GPS unit at a later stage in the project.

Additional hardware was required to store and distribute the data and for this purpose a high specification computer to act as a server was required. The server had the following specifications:

- A high speed processor (Pentium 4, 3.2 GHz)
- 1 gigabytes of Random Access Memory (RAM)
- A 128 megabyte graphics card
- 1 large capacity (80 gigabyte) hard disk drive
- A CD writer for backups

Software Requirements and Functioning Role

The software requirements for this project relate to the operation of the server and the connection and distribution of data over the internet. The software choices were limited to the available software licenses of the University of KwaZulu-Natal. The computer operating system was Microsoft Windows XP Professional[®]. The standard Microsoft Office Professional[®] suite of programs was installed, the key component being Microsoft Access[®] as the projects database is an Access database. Internet Information Server (IIS) is a standard component of the operating software (Strebe & Perkins 1997) which was installed. This allows anyone who knows the IP address, or URL linked to the PC's IP address, to be served the HTML welcoming webpages of the web-based GIS (Lammle *et al.* 1997).

Microsoft Frontpage[®] was used as the webpage authoring software for the preliminary webpage's as well as the individual webpage's relating to the imagery for each archaeological site in the GIS. The Environmental Systems Research Institute (ESRI) ArcGIS[®] 9 desktop GIS software was installed to manipulate particular datasets before final authoring in ESRI ArcIMS[®] 9.

ArcIMS[®] 9 Architecture & Functionality

The ESRI ArcIMS® 9 software package is the core of the web GIS delivery system and as such needs to be discussed in some detail. The sole purpose of this software is to publish maps, data and metadata on the web. Figure 2 shows the multitier architecture of the system (ESRI 2004).

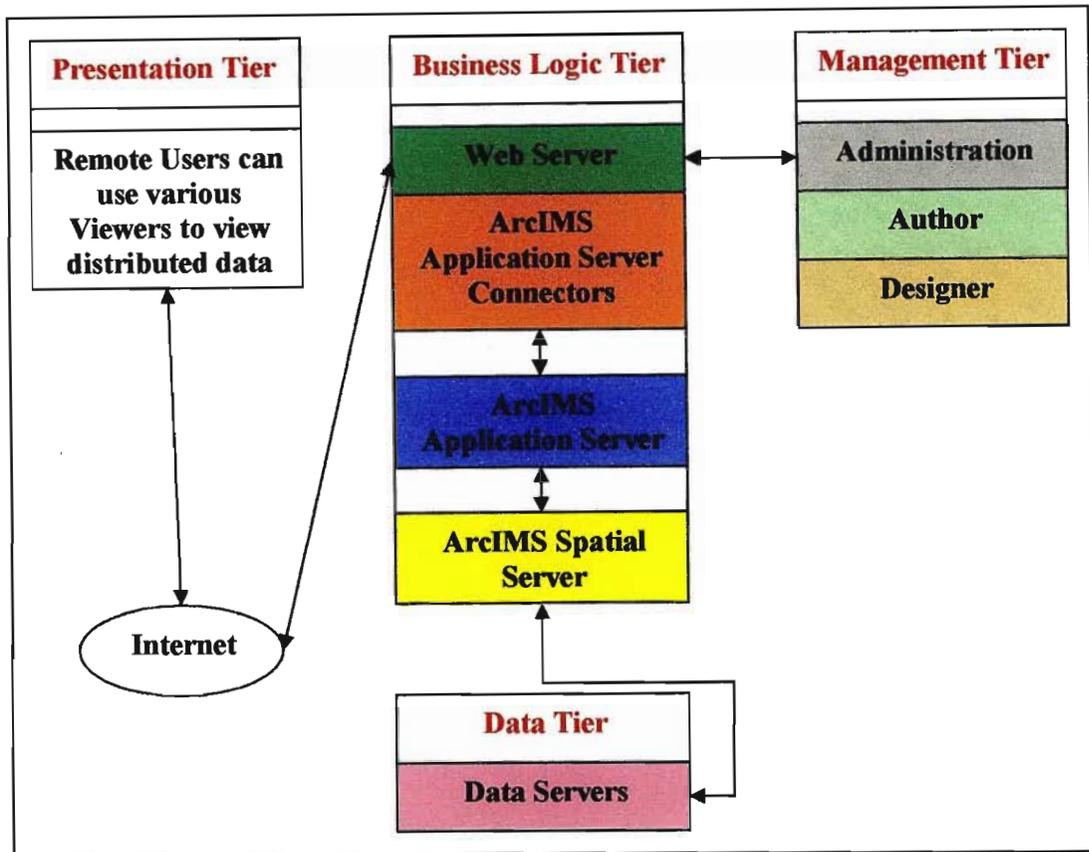


Fig.2. Graphical representation of the ArcIMS® 9 multitier architecture.

The various tiers are the Data Tier, ArcIMS® Management Tier, Business Logic Tier and the Presentation Tier.

The Data Tier contains all the source data which is accessed by the Business Logic Tier for presentation over the web. This consists of the Microsoft Access® Database and all the individual ArcGIS® 9 datasets such as the road network, hiking path network, 20m contours, rivers, water points, planned firebreaks, unplanned burns, the background 1:10000 digital rectified and georeferenced orthophotographs and the location points of the archaeological sites in the case study area.

The ArcIMS[®] Management Tier accesses these raw data sets and through a process of using the Authoring and Designer modules within this tier, the administrator creates the base maps as well as the graphical presentation and functionality of each map distributed over the internet. Table 1 shows a selection of tools and their use created in the Designer module of the Management Tier.

Table 1. An example of some of the tools and their function selected during the design of a map.

Icon	Tool Name	Tool Use
	Toggle	Toggle between Legend and Layer List
	Toggle	Toggle overview map
	Zoom In	Zoom In
	Zoom Out	Zoom Out
	Zoom to Full Extent	Zoom out to full extent of map
	Zoom to Active Layer	Zoom to extent of the active layer
	Back to Last Extent	Zoom back to last extent
	Pan	Click and drag to move over map
	Pan by Aspect	Pans North, South, West and East
	Hyperlink	Click on feature of active layer to hyperlink to new document
	Identify	Click on feature of active layer and attributes open in bottom window
	Query	Query attribute table of active layer
	Find	Find feature by name
	Measure	Use to measure distance between features
	Set Units	Sets the units of measure on the screen
	Buffer	Can create a buffer around a feature/s by distance
	Select by Rectangle	Draw a rectangle around feature/s to select them
	Select by Line/Polygon	Select features by use of lines or polygons
	Clear Selection	Clears all previous selections
	Print	Prints map as per the present screen view

It is important to note that each map created normally consists of GIS datasets that may be manipulated in the same way as a desktop GIS system. On each map designed, a different selection of tools can be added for display with the map data. This allows the

administrator to restrict or enhance the remote users ability to manipulate the data. The Authoring module in the tier lets the administrator select which GIS datasets to incorporate into the final map presentation. These completed maps are then stored in the ArcIMS® Spatial Server ready for access within the Business Logic Tier on demand.

The Presentation Tier represents how the remote user will access, view and interact with the designed and authored maps that are stored in the ArcIMS® Spatial Server. The remote user can use a variety of viewers (clients) to access the data over the internet. ArcIMS® Viewers are built into the ArcIMS® software and are created in the design stage of each map. In this case, during the design stage it was decided to use the HTML Viewer to incorporate the hyperlink function that other viewers did not have. The hyperlink function is used to invoke the web page containing imagery of each individual archaeological site.

The Business Logic Tier handles requests for data from the Presentation Tier. The architecture of the Business Logic Tier is shown in figure 3.

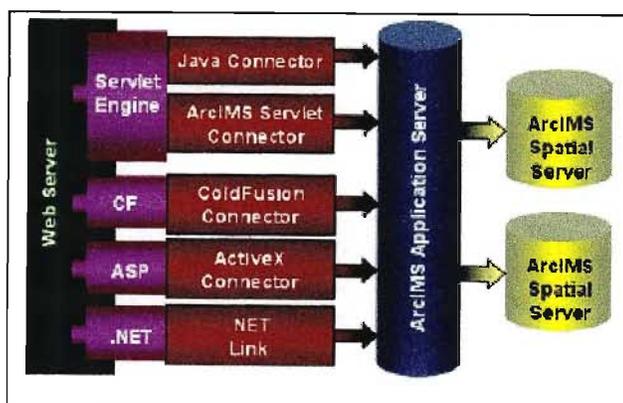


Fig.3. A graphical representation of the Business Logic Tier. (Taken from ESRI 2004)

A request by a remote client is passed over the internet to the web server, which in this case is IIS. Depending on what client was used to make the request the web server will then pass the request to the relevant application connector. The application connector converts all requests, no matter what connector is used, into ArcXML® which is a language that the ArcIMS® Application Server understands. The Application Servers role is to manage the retrieval and assembly of data from the ArcIMS® Spatial Servers.

The ArcIMS® Spatial Servers are the core of the system. They consist of seven server types namely, Image, Feature, Query, Geocode, Extract, Metadata and ArcMap® servers. In this case only the image server is used as again this server supports the hyperlink function deemed essential for this web-based GIS.

Database Design

A database is described by Howe (1989) as a collection of non redundant data that is sharable between different application systems. The core of this project is the background digital database that has been developed to serve as an archival, research and management tool. The application systems that access this database are a desktop GIS, a web-based GIS as well as a stand-alone interface as part of the database itself.

In the development of the database the minimum standards set by the South African Rock Art Data Archive (SARADA), which had been agreed to by all South Africa's museum curators and universities (Pearce 2005 pers.comm.) was taken into consideration. SARADA is an initiative of the Rock Art Research Institute (RARI) of the University of the Witwatersrand, South Africa.

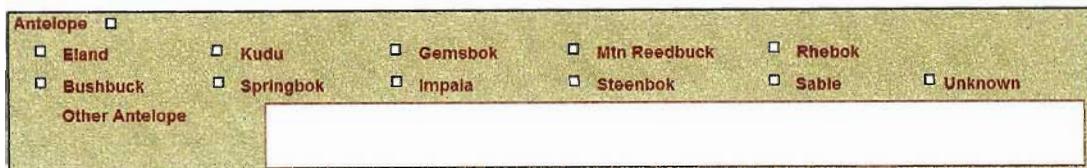
It was the RAMP view that as such an investment in time and effort was going to be made in collecting field data that the present database needed to be vastly expanded. A series of workshops were held that included key stakeholders. Some reservations about the vast expansion of fields in the database were expressed. This viewpoint was acknowledged but it was felt that a strictly objective classification system could paralyse possible future needs of researchers and managers. It must be remembered that as digital imagery is an integral part of the GIS any subjective input by one documenter can easily be corroborated or challenged by another by analysing the imagery and drawing new conclusions. This facility has not been available to date without extensive hardcopy archival retrieval and viewing by manual means (Swart 2004 pers.comm.).

The database design incorporates all the fields that were used by the Natal Museum to convert their paper records into their Microsoft Access® database. This enabled the importation of all the existing site data within the case study area. As far as individual fields go the Natal Museum database has 31 fields relating to rock art and the RAMP database has approximately 400 fields. As one can see the RAMP database contains the

possibility of twelve times more data fields than the original. The database fields are structured in such a way that the category options within each form would offer the documenter the opportunity to be:

- very objective i.e. choose not to fill in that form
- a combination of objective and subjective and choose a broad category description
- subjective, and fill in more descriptive options available.

An example of the proposed format is shown in figure 4 and it is clear that a documenter can choose to describe an image as just an antelope or can go deeper into the form and make the more subjective selection from the list provided or enter a written comment.



<input type="checkbox"/> Antelope	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Eland	<input type="checkbox"/> Kudu	<input type="checkbox"/> Gemsbok	<input type="checkbox"/> Mtn Reedbuck	<input type="checkbox"/> Rhebok		
<input type="checkbox"/> Bushbuck	<input type="checkbox"/> Springbok	<input type="checkbox"/> Impala	<input type="checkbox"/> Steenbok	<input type="checkbox"/> Sable	<input type="checkbox"/> Unknown	
<input type="checkbox"/> Other Antelope	<input type="text"/>					

Fig.4. The form entry format that allows documenters different levels of entry based on their own capabilities of identification and categorisation.

It was discovered that ArcIMS[®] 9 can only read attribute tables where the field names are all in uppercase and no longer than ten characters long. This was a significant limitation as in the design of a database with so many fields we had used upper and lower case and made the names as descriptive as possible. As a result it was decided to create a new table with new field names that met the requirements of ArcIMS[®] 9.

Data Inter-relationships

The database is a relational database constructed from ten tables. The main table is named MainSite and it contains the main SARADA components. This table is linked to nine other tables that are divided into relevant sections pertaining to each site. They are namely RockArt, Animal, HumanMen, RitualBeingWaterSpirit, Plant, ObjectStructure, DetailSiteDescription, SitePicture and Management. Figure 5 indicates the relationships between the MainSite table and the other linked tables which are 1 to 1 relationships except for the SitePicture table which is a 1 to Many relationship due to the possible large number of images that could be entered for each site.

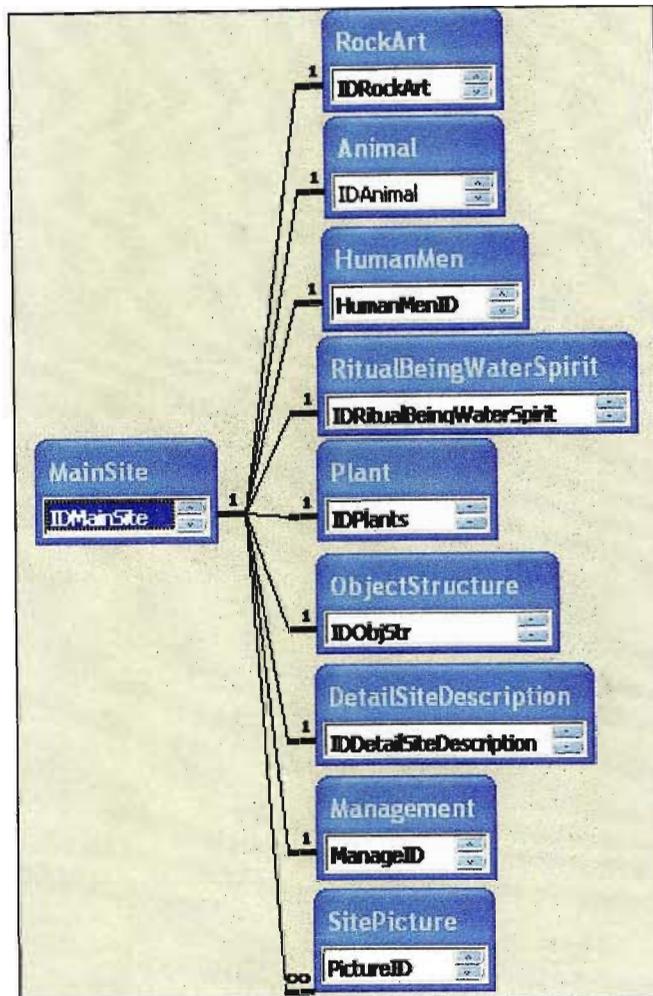


Fig. 5. Database structure and relationships.

Desktop GIS Datasets

Both the desktop and web-based GIS systems required background datasets. The most useful of these were the digital 1:10 000 scale black & white rectified aerial photographs. These were obtained from an aerial survey company. Each individual image covers approximately 5,5 km's by 5,5 km's on the ground. All the images have been georeferenced using the Gauss Conform Projection. This projection is based on using 2° belts of longitude with the odd degrees of longitude being the central meridian for each set. In the case of the Drakensberg this would mean using the 29° line of longitude as the central meridian. The Global Positioning System (GPS) constellation of orbiting satellites was used to obtain coordinates of each archaeological site in the World Geographic System 1984 (WGS84) reference datum and they were then projected using the Gauss Conform Projection resulting in coordinates in WG29. The Gauss Conform Projection reflects coordinates in y and x instead of showing coordinates in degrees, minutes and

seconds of latitude and longitude. The y coordinate being indicated in metres from the central meridian of 29° longitude, increasing to the West with 0 being on the central meridian. The x coordinate is indicated in metres positively from the equator southwards as shown in figure 6.

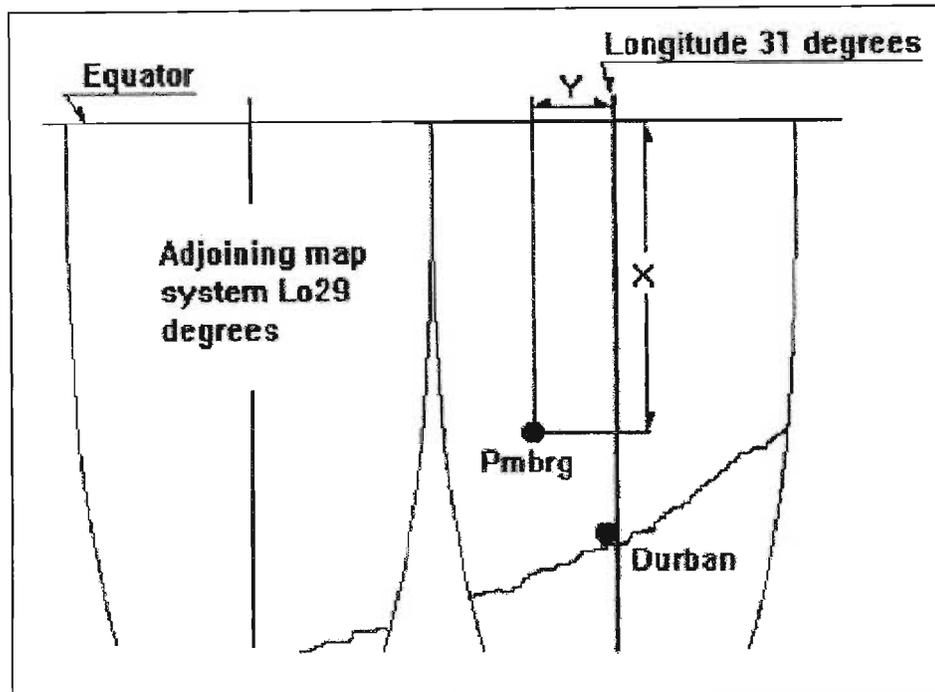


Fig.6. Example of the 2° Gauss Conform Projection (Taken from Jackson 2004)

There is a provision for entering these coordinates as well as the normal WGS84 degrees, minutes and seconds of longitude and latitude. This is necessary so that a data layer can be created from the database that shows each site location as a point in the GIS using the same datum (WG29) as the other data layers such as the background aerial imagery. This site location GIS data layer was created from the MainSiteTable where these coordinates are entered in the database so that the GIS layer is linked to this table and is indicated in the GIS as the main attribute table for each site position.

The following datasets were obtained from various sources; the 20m contours, rivers, hiking paths and roads. These datasets had to be re-projected to the WG29 datum within ArcGIS® 9 before transfer and incorporation in ArcIMS® 9. As one of the criteria considered when investigating a rock art site for possible opening to visitation is the location of water points (Nardell 2005 pers.comm.), an intersection overlay of the rivers

and the hiking paths was done followed by an extraction of the resultant intersection points creating a new point shapefile called “Water Points”. Other datasets created in ArcGIS® 9 included:

- planned firebreaks based on the baseline information obtained from the Officer-in-Charge of Cathedral Peak Conservation Area (Myeza 2005 pers.comm.)
- an un-planned burn, identified and digitized from the background digital aerial photographs as a polygon
- a ranger station that acts as the end of the road and start of the hiking path network in the area, identified and digitized as a polygon on the background digital aerial photographs
- a hypothetical campsite within the Valley of Pools created to highlight certain functionalities of the web-based GIS.

Web-based GIS Datasets

A limitation of ArcIMS® 9 is that one can only author maps using shapefiles and images in certain formats (ESRI 2005). Within the authoring component of ArcIMS® 9 one can only add shapefiles already produced. No manipulation functions are provided for. As such only the datasets prepared in ArcGIS® 9 above were included in the Valley of Pools map that was authored for distribution via the internet. In order to include the hyperlink function in the HTML webpage viewed by the remote user a section of code in the ArcIMS® parameter file had to be inserted. This code refers to which field name in the relevant attribute table should be used to find the hyperlink code. As such, the attribute table associated with the site locations had to have an additional field inserted that included the unique URL location of each webpage associated with that individual site record.

Website Security

It needs to be mentioned that the individual maps authored and designed in ArcIMS® 9 can be individually secured. Through the creation of an Access Code List (ACL) various usernames and passwords can be assigned to individual maps.

Field Data Collection

A portable document format (PDF) file was produced replicating the fields of the electronic database. This was used in the field to record all relevant details for each of the 12 sites recorded in the Valley of Pools for this project. Due to time constraints in the field only data for the MainSite table and the Management table were recorded. The attributes of these two tables are shown in table 2. Digital still images were taken for each site and included a general location image showing the site within the context of its immediate environment. Images of each individual rock painting or feature of significance (such as Dinosaur footprints) was taken for each site. A 360° digital video was taken at each site and included commentary such as the site name, date of videography and any obvious management or documentation issues that needed to be included. The position of each site was recorded with a handheld GPS unit.

RESULTS

The unique URL www.rockart.ukzn.ac.za points to the IP address of the server that hosts and distributes archaeological information over the internet. This site was opened to evaluation and testing for a period of two weeks with a background/instruction document and a questionnaire being sent to various interested parties.

The first webpage delivered to the remote user is the general welcome page as shown in figure 7.



Fig.7. The welcome webpage

Upon entering this site one is then presented with a map of the entire Maloti-Drakensberg Transfrontier Park, of which the uKhahlamba-Drakensberg Park is an integral part. One is then asked to select the area of interest. At this present time only the Cathedral Peak Conservation Area is active and coloured red. When one clicks on this area another webpage opens that displays the Cathedral Peak Conservation Area shown in figure 8. On this webpage one has the option of downloading or opening the attribute list with descriptions of the field names used in the GIS (table 2). This is important for people who are not familiar with the database. When one clicks in the red box area this opens up the HTML Viewer designed in ArcIMS® 9 for the Valley of Pools.

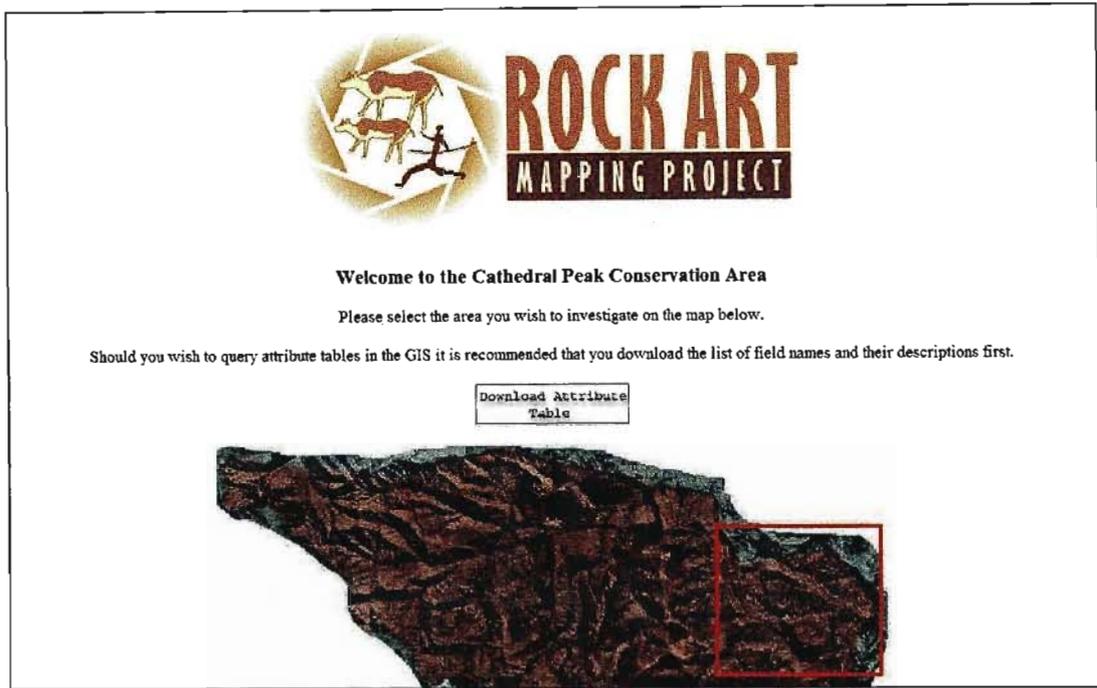


Fig. 8. The Cathedral Peak Conservation Area webpage showing the area of the Valley of Pools

Figure 9 shows the graphical presentation of the web-based GIS.

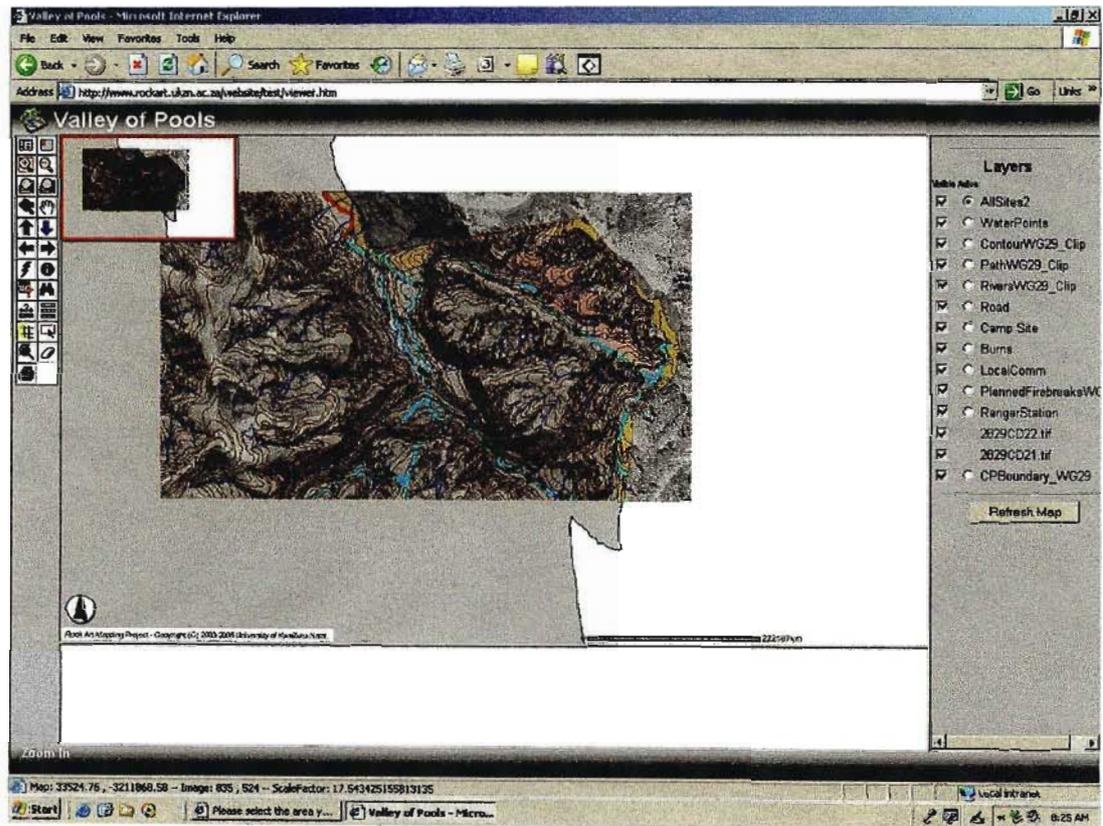


Fig.9. Graphical display of the web-based GIS as it first displays to the remote user.

In the left hand frame of the window are the functionality buttons used to interrogate and manipulate the various datasets shown in the main window. In the right hand frame are the various layers containing the individual datasets. When the HTML Viewer first opens all the layers are selected as being visible and the top most layer is selected as the active layer.

Various functions were used to highlight the functionality of the web-based GIS. First of these was the buffer. According to the South African Heritage Resource Agency's Minimum Standards for Archaeological Site Museums and Rock Art Sites open to the Public (Undated) it is suggested that no campsite should be positioned within 500m of any site. Within the GIS it is a case of making the layer 'AllSites2' active, selecting all the sites using the select by rectangle tool and then using the buffer tool, request a graphical representation of a 500m buffer around all the sites in the valley. This produces the image in figure 10 clearly showing where a campsite should not be placed.

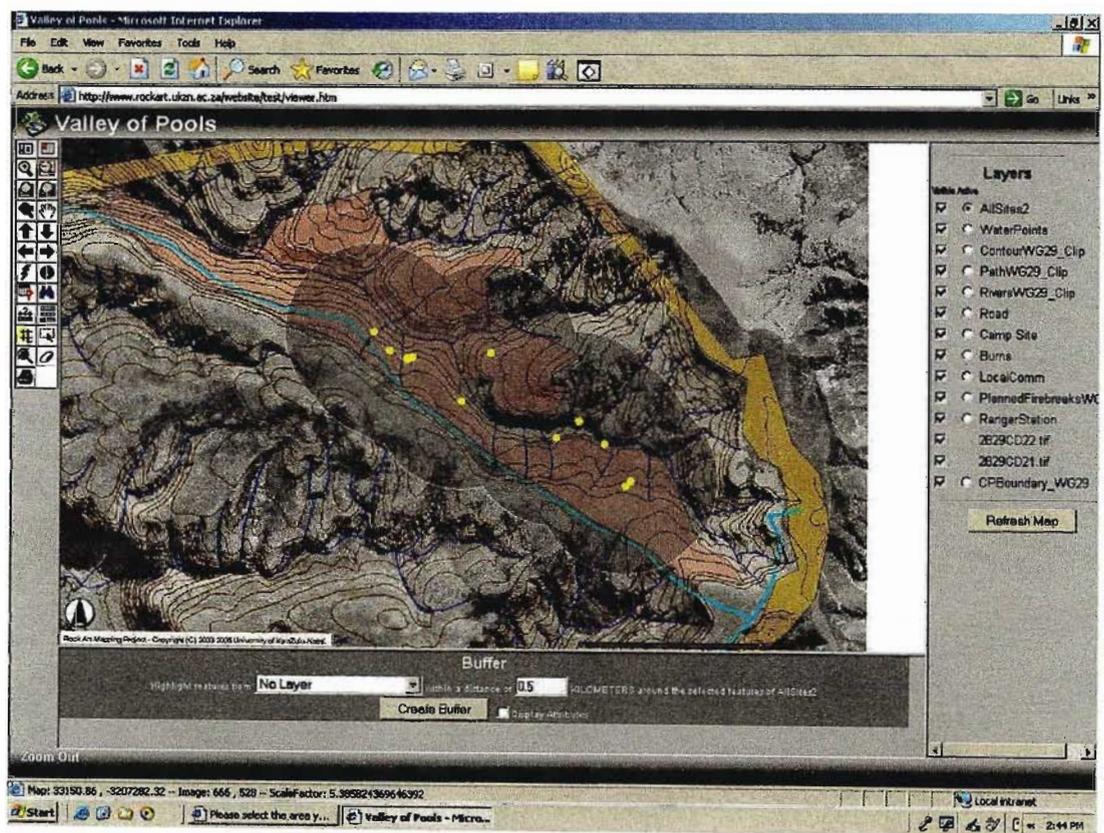


Fig.10. The camping buffer around all the sites in the valley.

Supposing that a campsite already existed in the valley one could use the buffer function to determine which sites would be impacted and investigate accordingly. In this case the 'Camp Site' layer is made active and again selected with the select tool. The buffer tool is then used to select any site that falls within the 500m buffer requested. The result is displayed in figure 11.

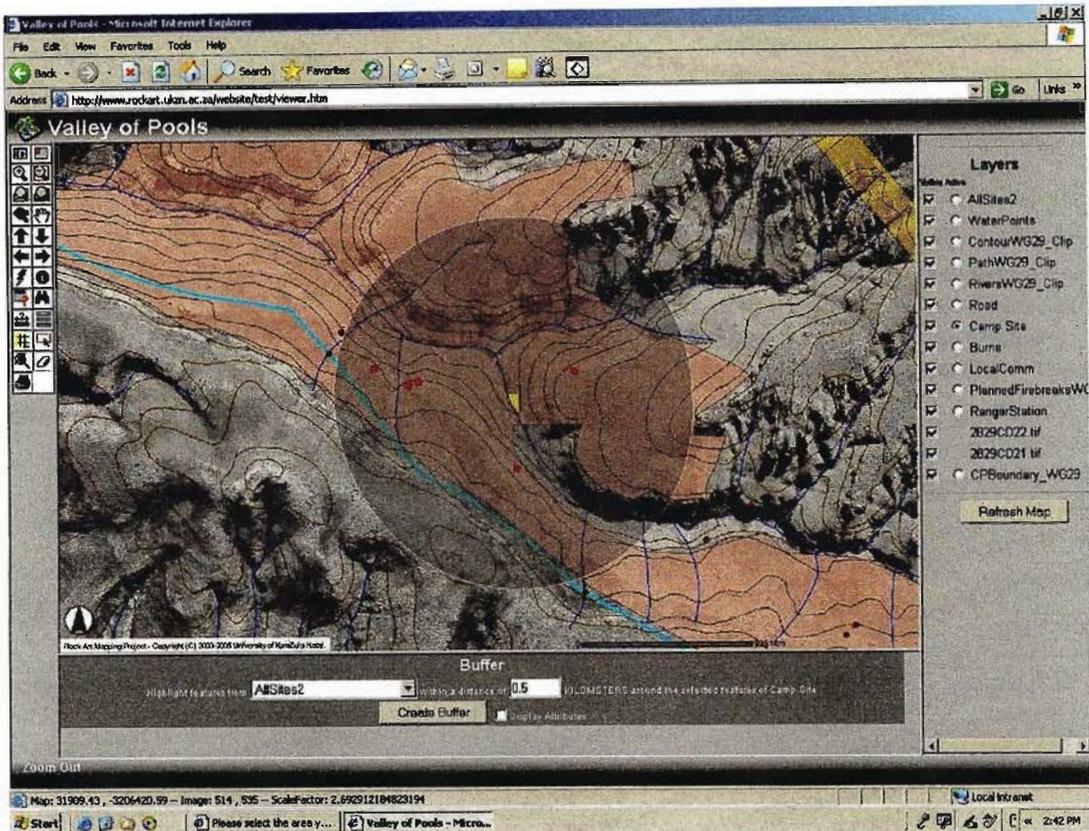


Fig.11. Buffer around hypothetical camp site showing all impacted sites within 500m.

The hyperlink tool can then be used to investigate each site further. To do this one makes the 'AllSites2' layer active and using the hyperlink tool clicks on the point representing the site. This opens up another window in which there is displayed all the graphical content relating to that site. This includes a location image as well as individual painting images. The video can also be downloaded or opened from this webpage. This is shown in figure 12. Notice that the location image includes a red arrow to focus the user on the exact location of the images within the site as well as the sites location within its environment. This window can be maximized and remain open in the background while further investigation takes place.

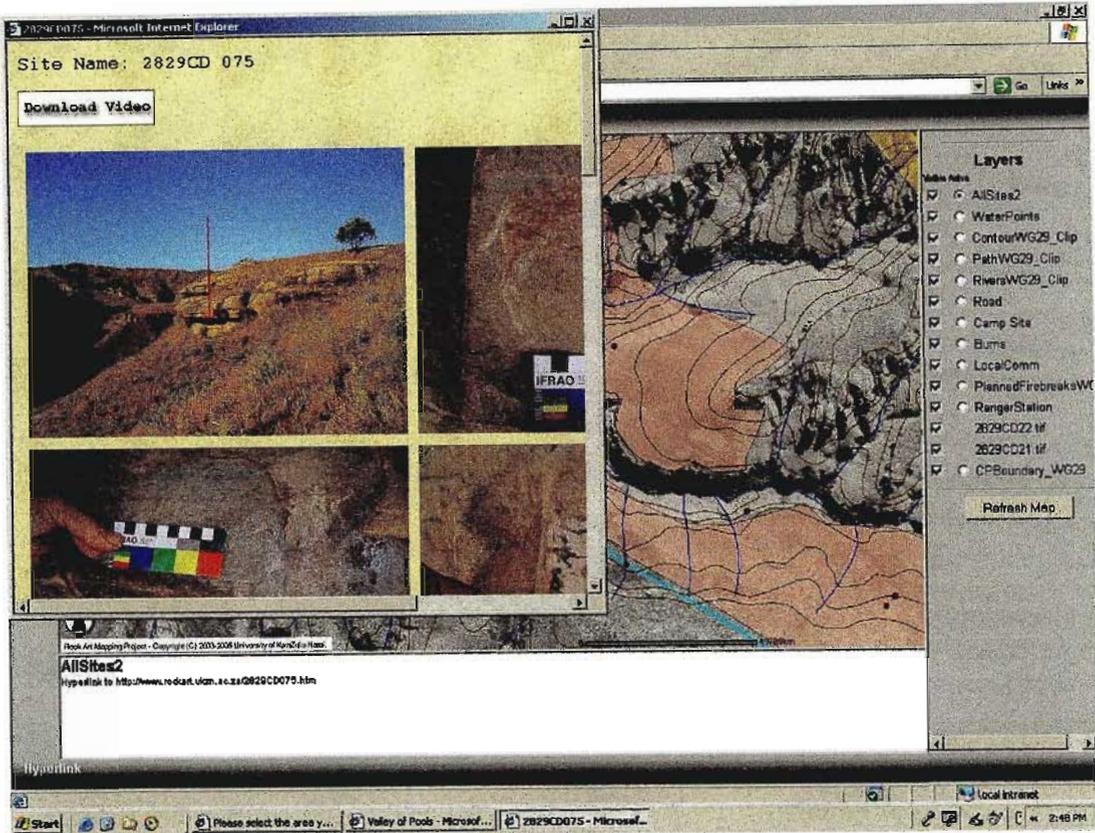


Fig.12. Hyperlink tool activates the graphical data available for the chosen site under investigation

A major element of the GIS is that one can use the query tool to compile simple to complex queries of the associated attribute table that result in a graphical display. An example shown below is a query of which sites have been or could be damaged by fire. This is done by making the 'AllSites2' layer active and then using the query tool to compile the query string as shown in figure 13.



Fig 13. When selected the query tool opens this window in the bottom of the frame and the query string or multiple strings can be compiled using any field in the table and a selection of operators.

The result of this query is that all the sites that have been or could be damaged by fire in the valley are highlighted as shown in figure 14. This can then be graphically interrogated against the background 'Burn' layer to see if any of these threatened sites have fallen into

the burned area. Conversely this could be done before the remote manager plans the areas for controlled burns and firebreaks, specifically to protect these vulnerable sites.

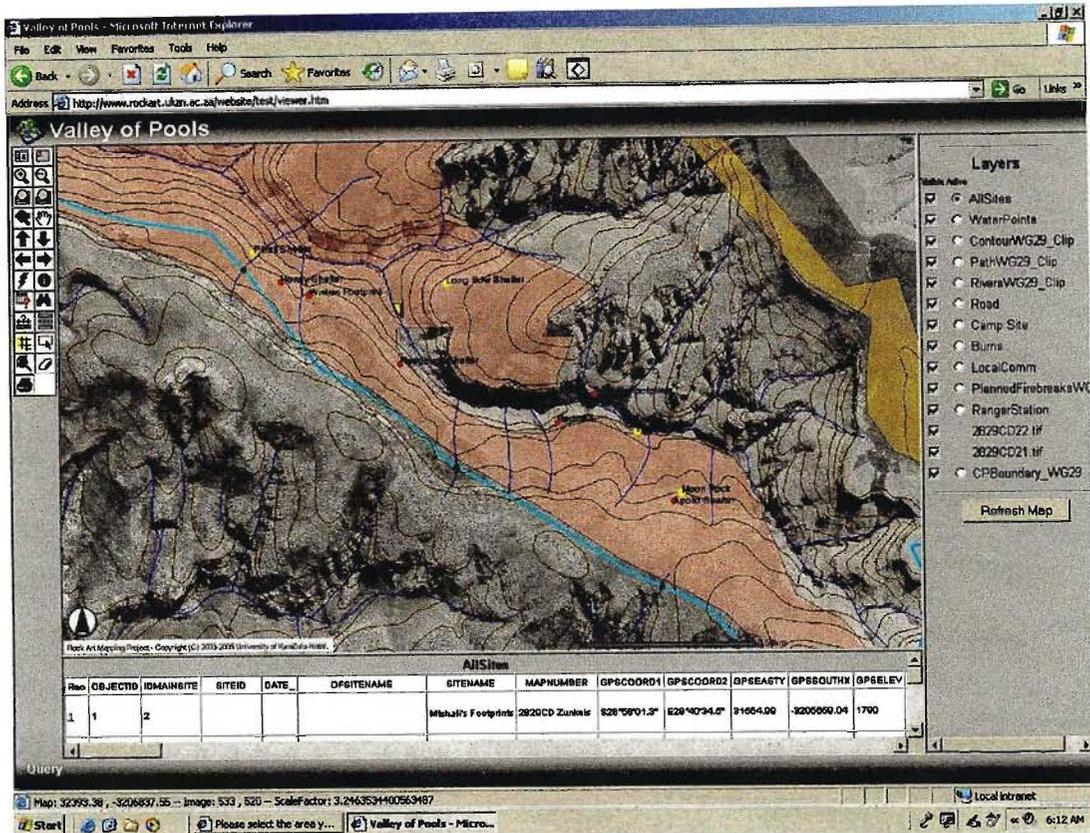


Fig. 14. Results of query showing all sites threatened by fire in yellow

When sites are selected in the main window, their attributes are displayed in table form in the bottom window. The remote user can scroll through the entire attribute table to view the non spatial information on each site. The information contained in this attribute table is shown in table 2 and consists of all the field names in the combined table.

Table 2. Showing all field names and short description of field contents.

Field Name	Description
SITEID	Official site number ie. 2829CD070
DATE	Date of entry into database
OFSITENAME	Official site name ie. Cathedral Peak State Forest
SITENAME	Local site name ie. Poozle
MAPNUMBER	1:50000 mapsheet number ie. 2829CD Zunkels
GPSCOORD1	GPS Coordinate in degrees, minutes and seconds South
GPSCOORD2	GPS Coordinate in degrees, minutes and seconds East
GPSEASTY	Y Coordinate
GPSSOUTHX	X Coordinate
GPSELEV	Elevation of site

SHELTER	Is the site a shelter
CAVE	Is the site a cave
FREESTAND	Is the site freestanding
BEDROCK	Is the site in bedrock
SITETYPE	What type of site is it. Relates to choices above
KNOWNPRIOR	Was the site previously recorded
DEPOSIT	Was there any archaeological deposit visible
YESDETAILS	If known prior then list details here
DEPDETAILS	If there was deposit describe here
RECPERSON	Who is the latest recording person
RECTEAM	Which institute/team does that person belong
RECNUMBER	Date of latest recording
FSTRECPER	First person to record site
FSTRECDATE	Date of first recording
FSTRECINST	Institute/team of first person to record
ASPECT	The aspect of the site
DIRECTIONS	Directions to the site
SIGHIGH	Is the significance of the site high
SIGMED	Is the significance of the site medium
SIGLOW	Is the significance of the site low
SIGREASON	The reason for the choice above
PRIORITYH	Is the priority for this site high
PRIORITYM	Is the priority for this site medium
PRIORITYL	Is the priority for this site low
PRIREASON	The reason for the choice above
THREATSH	Is the threat to the site high
THREATSM	Is the threat to the site medium
THREATSL	Is the threat to the site low
THREASON	The reason for the choice above
DAMWATER	Does the site show signs of damage by water
DAMGRAFF	Does the site show signs of damage by graffiti
DAMFIRE	Does the site show signs of damage by fire
DAMEROSION	Does the site show signs of damage by erosion/exfoliation
DAMHUMANS	Does the site show signs of damage by human occupation
DAMANIMAL	Does the site show signs of damage by animal/insect occupation
DAMVEGET	Does the site show signs of damage by vegetation
DAMDESCRIP	Description of the damage
MANAGEMENT	Management suggestions
LSTASSDATE	Last date of management assessment
LSTASSPERS	Last person to carry out a management assessment
LSTASSAFIL	Which institute/team is the person affiliated to
LASTASS	Shows historic record of assessments
LANDOWNER	Who is the land owner on which the site occurs
LOCONTDET	Land owners contact details
LOCALAUTH	Local authority responsible for the management of the site
LACONTDET	Local authority contact details
OPENSITE	Is the site open to the public
LOCCOMACC	Does the local community have access to the site
MONITOR	Is the site monitored
YESWATER	Is there water available
WATERWHERE	Description of water availability
WEBSITE	Hyperlink to the sites unique webpage containing images and other graphical data

This information table is available for downloading or display before the web-based GIS is activated and is necessary for a remote user to interpret the meaning and contents of the fields in the attribute table in order to carry out meaningful queries.

The measurement tool can be used to measure horizontal length of paths or any other required item. The slope of any section of path can be investigated as one has the 20m contours to indicate a vertical difference in height. Using the formula below one can determine the slope of any section of path between a selected number of contour lines.

Tangent $A = \frac{a}{c}$ where a is the vertical height difference and c is the horizontal distance.

A is the slope in degrees. Using this formula it can be seen that should a horizontal distance of 34.64m or less be measured between any two contour lines then that section of path has a slope greater than 30° .

DISCUSSION

The results above clearly show the varied functionality of the web-based GIS. Table 3 shows how the web-based GIS can be used in relation to the key issues within different management sectors as defined by Amafa (2005). Note that these tables are work in progress at the time of writing this paper.

Table 3. Shows functionality of web-based GIS for key issues within sectors of rock art management.
(Modified from Amafa 2005)

Generic Management Plan for Rock Art Sites		
	Web-based GIS	Comments
Institutions		
<i>Key Issues</i>		
Integrated management as part of the natural environment	Yes	The still and video imagery can be interrogated. Variety of datasets can be added. Fire query is an example
Appointment/designation of staff	No	
Training of staff	Yes	Web-based GIS could be a valuable training tool not only for rock art management but all aspects
Access for management to information (database)	Yes	Web-based system would allow for maximum access to centralised database and datasets
Joint management of the cultural environment	Yes	Web-based system would allow multi-disciplinary use and input into management decisions
Physical Conservation		

<i>Key Issues</i>		
Vandalism	Yes	These issues are covered in the existing database and interrogation of the imagery would reveal state
Graffiti	Yes	These issues are covered in the existing database and interrogation of the imagery would reveal state
Human agency	Yes	These issues are covered in the existing database and interrogation of the imagery would reveal state
Dust mantles	Yes	These issues are covered in the existing database and interrogation of the imagery would reveal state
Wind erosion	Yes	These issues are covered in the existing database and interrogation of the imagery would reveal state
Exfoliation	Yes	These issues are covered in the existing database and interrogation of the imagery would reveal state
Rock falls	Yes	These issues are covered in the existing database and interrogation of the imagery would reveal state
Water damage	Yes	These issues are covered in the existing database and interrogation of the imagery would reveal state
Fading	Yes	Interrogation of the imagery would reveal state
Consumptive use of paintings	Maybe	Difficult to determine from still imagery but could be added as audio in the videography
Unauthorized access	Maybe	Only if specifically mentioned in database or audio of videography
Documentation & Research		
<i>Key Issues</i>		
Management of database	Yes	One centralised and distributed database via a web-based GIS is easier to maintain than a number of distributed databases
Centralization of information	Yes	One centralised and distributed database via a web-based GIS is easier to maintain than a number of distributed databases
Research permits	Yes	Would need to add a field into the database showing who has permit to research that site.
Research policy	No	
Recording of new sites	Yes	A web-form could be added so that remote user could submit new discoveries for further field investigation
Research topics	Yes	The entire GIS is highly suited for research purposes as it delivers a quick graphical response to the most complex queries
Landscape Setting		
<i>Key Issues</i>		
Land management	Yes	Various relevant datasets could be added to the GIS
Rock falls	Yes	Could be added as a dataset
Path maintenance	Yes	Intensity use could be added as a dataset
Fire risks	Yes	Sites at risk can be highlighted and planning accordingly
Fire breaks	Yes	Sites at risk can be highlighted and planning accordingly
Arson burning	Yes	Sites at risk can be highlighted and planning accordingly
Domestic animals	Maybe	Would need to be mentioned specifically in the database
Local communities	Yes	Local community access is mentioned in the database
Living heritage aspects of the landscape	Maybe	Still and video imagery can be interrogated but would need more input in the database
Tourism		
<i>Key Issues</i>		
Unauthorized access	Maybe	Only if specifically mentioned in database or audio of videography
Hiking clubs	No	
Closed versus open sites	Yes	Decisions based on interrogation of imagery and database
Managed versus unmanaged sites	Yes	Decisions based on interrogation of imagery and database

Trendiness of rock art	No	
Pilgrimage experience	Yes	Decisions based on interrogation of imagery and database
Access control	Yes	Decisions based on interrogation of imagery and database
Path maintenance	Yes	Intensity use could be added as a dataset
Signage	No	
Custodians	No	
Custodian training	Yes	Web-based GIS could be a valuable training tool not only for rock art management but all aspects
Living Heritage		
<i>Key Issues</i>		
Drakensberg San descendants and other Khoisan forums	Maybe	If specific mention is made in the database or audio of videography
Traditional healers	Maybe	If specific mention is made in the database or audio of videography
Pigment for muti	Maybe	If specific mention is made in the database or audio of videography
"new age" user groups	Maybe	If specific mention is made in the database or audio of videography
Shepherds	Maybe	If specific mention is made in the database or audio of videography
Livestock rustlers	Maybe	If specific mention is made in the database or audio of videography
Tourists	Maybe	If specific mention is made in the database or audio of videography
Researchers	Maybe	If specific mention is made in the database or audio of videography

Besides showing the perceived functionality of a web-based GIS as described above, a questionnaire was sent to various institutions and individuals, both nationally and internationally. The criteria used for the selection of recipients was based on the institutions/organisations involvement, or in depth knowledge, of the present issues surrounding rock art management and conservation in South Africa. The individuals targeted were Archaeologists with a known interest in rock art management and conservation. As such the sample size was limited due to the low number of institutions/organisations and individuals involved in rock art management and conservation in South Africa. A geographical spread was obtained covering all major occurrences of rock art in South Africa. It was assumed that the recipients of the questionnaire would not be familiar with the operation of a GIS and as such the questionnaire consisted of only four core questions. The questionnaire was accompanied by a background document on the project as well as a detailed instruction sheet on the operation of the web-based GIS. Table 4 shows those institutions/organisations and individuals targeted, number of people within the institution/organisation targeted and the number of responses received.

Table 4. Shows targeted institutions/organisations and individuals and the responses received

Institute/Organisation/Individual Targeted	No. Targeted	No. Responses
Natal Museum	3	1
Amafa aKwaZulu-Natali	1	1
Maloti-Drakensberg Transfrontier Project	1	1
Rock Art Research Institute (RARI)	3	0
Rhodes University	1	0
University of Cape Town	1	0
National Museum Bloemfontein	1	0
Mapungubwe Museum	1	1
South African National Parks	1	0
South African Heritage Resource Agency	3	0
Ezemvelo KwaZulu-Natal Wildlife	3	1
McGregor Museum	1	0
Western Cape Nature Conservation (Cape Nature)	1	1
Getty Conservation Institute	1	2
Individuals	6	1
Total	28	9
Response rate	32%	

Table 5 shows the analysis of the returned questionnaires rated on a scale of 1 – 5 with 1 being the poorest rating and 5 being the highest rating possible.

Table 5. Respondents rating of the web-based GIS

Question	No. of Respondents for each rating category					
	Rating Scale	1	2	3	4	5
Speed of welcome page				3	6	
Navigating to the web-based GIS				3	6	
Functionality w.r.t. rock art management			3	2	3	

Usefulness of web-based GIS to organisation			1	1	7
---	--	--	---	---	---

All of the respondents rated the speed of downloading the welcoming page as between 4 to 5. All of the respondents rated the ease of navigation to the web-based GIS as between 4 to 5. The functionality of the web-based GIS with respect to rock art management was rated at 3 by 33% of the respondents. 11% could not give a rating as the site did not open for them. 22% rated this area of functionality at 4 and 33% at 5. The usefulness of the web-based GIS to the respondents particular organisation was rated as between 4 to 5 for 88% of the respondents and a 2 rating by 11% of the respondents. The web-based GIS opened and appeared as it should have for 88% of the respondents. Those that it did not open for were using an outdated web browser not supported by ArcIMS® 9 and thus could not assess the functionality of the system. Due to the small sample size and response rate these statistics should be treated with circumspect. Perhaps a more relevant assessment could have been achieved through the medium of a national workshop demonstrating the product. Due to practicalities and time constraints this was not possible.

CONCLUSIONS

It is clear that the web-based GIS delivers content that the present system in KwaZulu-Natal does not. The functionality of the GIS is perceived by some users as lower than that which is shown in the generic rock art management tables. A web-based GIS would address many of the issues surrounding a centralized database and access to that data by relevant authorities and managers. The quantity and quality of spatial and non-spatial data that the web-based GIS delivers can most certainly be used as a tool for rock art management in the future.

RECOMMENDATIONS

A number of recommendations have been made to improve the system. They include the addition of more datasets relevant to rock art management as well as other integrated management functions. The background database needs to be re-visited to include additional information with regards to management information as well as the re-naming of field names to meet the specifications of ArcIMS® 9. Funding now needs to be sought for the population of the database and assembly of all relevant datasets.

ACKNOWLEDGEMENTS

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APPENDICES

Appendix 1: EKZNW Project Application Form

Rock Art 3D Digital Mapping Project

RESEARCHER:

Programme of Geomatics (Land Surveying), University of Natal, Durban
King George V Avenue, Durban, 4001

SUPERVISOR:

Mr Angus Forbes
Programme Director
Programme of Geomatics (Land Surveying), University of Natal, Durban
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CO-WORKERS:

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Programme of Geomatics (Land Surveying), University of Natal, Durban
King George V Avenue, Durban, 4001

<u>KZN WILDLEFE CO-ORDINATOR:</u>
--

PROJECT LEVEL:

This project is of national importance

OBJECTIVES:

The Project has four key objectives, namely:

1. To digitally archive and map all the rock art sites within the Ukhahlamba Drakensberg range using terrestrial photogrammetry.
2. To create a Geographical Information System (GIS) website for researchers and educational institutions which will record, inter alia, the condition and location of each site as well as provide an accurate source of mapping data that can be used for research purposes. An aspect of this website (or an additional stand alone website) will display the national heritage to the general public in a way that protects the location of such sites and meets all security issues.
3. To use this opportunity to place a team in the field for a long period of time with the sole aim of conducting a detailed exploration of the area for additional, unrecorded rock art sites.
4. To create long term permanent employment opportunities within the local community which would involve eco-tourism and training.

RATIONALE:

Problem Statement

At this present time there are a number of institutions and organizations that hold and safeguard hard copy elements of this national treasure and heritage. There have been numerous methods of doing so over the ages such as hand written recording, photographs, slides and life size tracings. One of the problems that such a collection poses is that it is very difficult to give access to the general public. Another threat is that of destruction of the collection. The material is bulky and difficult to store and expensive protection methods are needed to safeguard these collections. Should any one of these collections be destroyed for any reason it would be a major blow to our heritage.

As technology moves forwards other more appropriate methods of capturing and storing this valuable data is being presented to us. The latest techniques involve the digital colour photographing of these sites from which accurate three dimensional colour maps can be produced (colour rectified and in digital form) and can be displayed. This process is known as terrestrial photogrammetry. Such data can be accessed by researchers for accurate studies and data can also be presented to the general public via a website. Obviously this data needs to be protected, especially the geographical location of these sites. Ownership and dissemination of this data should reside with a trusted and recognized organization.

Implementation Strategy

First phase Planning and Inception

The project requires a focused and aligned stakeholders group to function and accordingly, the first phase is to set-up structures to manage and implement the project. During this phase, the Implementing agency will determine whether existing structures are suitable for the project and if not, establish structures at each of the focus regions.

During this phase, a field trip will be undertaken to a sample of key sites to determine final modus operandi. A comprehensive report, on activities in the region as well as an analysis of local optimum factors will be produced at this stage to guide future development of the project.

A stakeholders forum will be established, whose purpose it will be to disseminate information on the projects progress and to guide overall project focus. It is not the intention to create a body of bureaucracy but rather a consultative body, who are informed of developments by the dedicated exploration and mapping teams.

The project does not aim to become a talkshop, but will serve as a functional, effective unit, creating a valuable resource and service for researchers, heritage roleplayers and the general public internationally.

Team members will be recruited and training will commence.

Second phase Preliminary exploration, mapping and training of personnel

The project would move into its second phase with operations taking place in the field and the first data mapping occurring. Team leaders will be familiarizing themselves with the area. Full scale mapping will commence once everyone is trained in their specific role.

Third phase Production, Monitoring and Evaluation

Mapped data will be transferred from the field to the University of Natal where processing will take place. The GIS will be constructed and the website developed and secured. The first finished product for general public viewing will be released. Monitoring and evaluation of the project will be carried out and reported on.

Outputs

In terms of Objective **One**, the output is

- A set of calibrated and oriented digital photographs containing complete stereographic coverage of each site.
- A surface model (virtual cave) of each site.
- High quality calibrated digital ortho-rectified photography of each painting.

In terms of Objective **Two**, the output is

- A GIS containing information (including links to the outputs from objective one above) pertaining to rock art sites.
- A secure server limiting Internet access to the GIS system to approved researchers.
- A website containing GIS data containing information from the GIS relating to non-sensitive tourist oriented sites.

In terms of objective **Three**, the output is

- A locally recruited and trained team leader will lead a detailed and thorough exploration of the area in which the mapping team is working.
- All new and unrecorded rock art sites will have a GPS position and a general description.
- This information is passed onto the mapping team who will include the latest sites into their mapping schedule.

In terms of Objective **Four**, the output is:

- The recruitment of two survey technicians or students -in -training from previously disadvantaged backgrounds in KwaZulu Natal. The necessary training will be provided by the University Of Natal, Programme of Geomatics (Land Surveying).
- The recruitment of two team leaders selected from the local community. They will be trained as field guides as well as heritage guides.
- The recruitment of three general assistants from the local community. They will receive all the training necessary for their functions.
- The recruitment and training of one security guard from the local community.

STUDY AREA:

The project would commence in the Royal Natal National Park, the Northern Drakensberg and head south towards the Mweni Valley and ending in the Southern Drakensberg.

TIMING:

The commencement of the project will be determined by the receipt of funding. The initial time frame set out is for an 18 month period although the completion of the project is expected to take a number of years.

STUDY PROCEDURE:

At each site accurate national coordinates will be brought in using realtime GPS ground surveying techniques. Inside each site accurate camera stations will be coordinated using a high level theodolite and conventional ground survey techniques. From the camera stations (number will depend on the rock face layout) full stereographic coverage of the paintings will be recorded digitally. Each image will have a colour chart included so that colour rectification (uniformity) across the entire image set can be achieved. Stereographic coverage of the external view from the site will also be taken.

This data will be recorded onto a laptop on site and later transferred to the University of Natal where it will be processed. From this data a 3 dimensional map of the cave and its contents will be created in a digital format.

KZN WILDLIFE ASSISTANCE:

FUNDING:

Funds provided by:

National Lotteries Board has approved an initial amount of R 3,077,270.00 (Three million and seventy seven thousand two hundred and seventy Rand) for the first 18 month phase. Please see attached Application for Funding No. 10153

Funds requested from KZN Wildlife: R0

APPROVED:	AMOUNT:
------------------	----------------

ACCOMODATION:

The team would require camping space at the nearest campsite at each general location to set up a base camp infrastructure. Field teams would camp in the general area to each site cluster.

As we would be moving from area to area we cannot specify dates as of yet and this would probably have to be negotiated in the field closer to the time for each area move.

Coordinator: Normal charge: Discount recommended:
--

APPROVED: (HBP)	CHARGE:
------------------------	----------------

MANPOWER:

Requested: No direct manpower but help with the selection of local community members for training and employment on the team would be appreciated if not essential.

APPROVED:

EQUIPMENT USE:

Requested: None

APPROVED:

The project has been accepted by KZN Wildlife, and the study may now commence.

Supported:

Regional Conservation Coordinator Date

Scientific Divisional or Section Head Date

Approved:

Head Biodiversity & Planning Date

Registration Number

Appendix 2 Copy of Natal Museum Site Record

Note. All references to location have been removed for security purposes

**NATAL MUSEUM
ARCHAEOLOGY DEPARTMENT**

MUSEUM SITE NUMBER: S939AB

SITE CATEGORY; Rock Art and Later Stone Age

RECORDER'S SITE NUMBER:

MUSEUM CATALOGUE NUMBER:

MAGISTERIAL DISTRICT: Estcourt.

MAP SHEET:

MAP REFERENCE:

OFFICIAL NAME: ??????? 7129

LOCAL NAME: ??????? Rock I

DIRECTIONS TO SITE:

Take path to ??????. When path approaches upper sandstone band and before going around into valley there is a large rock on the right of the path. To the left of the path at this point there are 2 rock overhangs. The one on the left is Solitude Rock I,

DESCRIPTION OF SITE;

N.E. facing overhang formed by several rockfalls which is about 7 metres long, 2-3 metres deep and 2 metres high. Has no natural screening. Good outlook across around down valley. Seepage present on the rockface. Steep slope in front, Water freely available. Floor covered with sand vegetation and rocks, (and today with hail) No deposit.

DESCRIPTION OF ARCHAEOLOGICAL CONTENT OF SITE:

Pottery on the *surface*.

Paintings: 1 indeterminate human.

Art description

From left and ± 0 cms from the ground; indistinct red paint. Up 55 cms: red human facing left. Its right arm diagonally down in front and left arm bent forwards behind its back, protruding from front, crossing stomach and holding horizontal stick which crosses stomach and protrudes back and front.

OWNER: Natal Parks Board.

RECORDER: Name: A.D. Mazel

Address: Natal Museum

SOURCE OF INFORMATION:

Visit

Date: 29/1/80

DETAILS OF RECORDING, INCLUDING COLLECTING:

Colour slides and monochrome photography.

1980/11.

REFERENCES:

Appendix 3 Copy of the new PDF field site recording form

Main Site Details

GPS South GPS East Map Nr

Official Site Name Site Nr

Local Site Name Elevation

First Recorded by Aspect

Institution / Project 1st Rec Date

Recorded By Rec Date

Project

Type of Site

- Shelter Cave Freestanding Bedrock
 Known Prior Archaeological Deposit / Artefacts

If Known Prior, Details

Archaeological Deposit / Artefact Details

Directions to Site

Key Recognisable Image Description

Site Identification Picture

Key Recognisable Image

Rock Art Details

SITE ID

Probable Affinity

- San Khoi Bantu European Unknown

Year

Contact Art

- European Rifles Cattle Horses Wagons Ship Fight Scene
- Black Spear Throw Assegaai Stab Axe Shield
- Cattle Fight Scene
- Khoisan Cattle Sheep Fight Scene

Other Contact Art

Painting

- Monochrome Bichrome Polychrome
- Shaded Crayonlike Brush stroke Unknown

Prints

- Hand Plain Left Right Hand Decorated Left Right
- Finger Painting Finger Dots Finger Smudge / Smear Unknown

Pigments

- Red Orange Brown Yellow
- Black White Purple Unknown

Engraving

- Etched Pecked Carved Unknown

Other Rock Art

Animal Details

SITE ID

Large Mammals

- Elephant Hippo Rhino Giraffe Buffalo
 Hartebeest Wildebeest Roan Zebra

Other Large

Medium Mammals

- Aardvark Wilddog Hyena

Other Medium

Small Mammals

- Warthog Bushpig Monkey Jackal Fox
 Dassie Porcupine Baboon Aardwolf Genet

Other Small

Felines

- Lion Leopard Cheetah Small cat

Other Feline

Antelope

- Eland Kudu Gemsbok Mountain Reedbuck
 Rhebok Bushbuck Springbok Impala
 Steenbok Sable

Other Antelope

Animal Details

SITE ID

Spoor

- Lion Eland Human Track / Game path Line Spoor

Other Spoor

Birds

- Ostrich Vulture Eagle Raptor Swallows
 Guinea Fowl Francolin Blue Crane Ducks / Geese Hammerkop

Other Birds

Aquatic Animals

- Morymid Fish Eel Catfish Yellowfish
 Frog Crab Whale

Other Marine and Fresh Water

Reptiles

- Crocodile Snake Turtle Tortoise Lizard
 Chameleon Saurian Figure

Other Reptilian

Insects

- Bees Beehive Grasshoppers Moth Flying Ants

Other Insects

Animal Details

SITE ID

Domesticated Animals

- Cattle Dogs Greyhound Whippet Small Robust dogs
 Sheep Fat-tail Sheep Thintail Sheep Horses Chickens

Other Domesticated

Extinct animals

- Quagga Cape Mountian Lio Bluebuck Giant Buffalo

Other Extinct

Symbolic Details

SITE ID

Rain Animals

- Bull Eland Elephant Giraffe Kudu
- Bird Hippo Feline Pig Serpent
- Ghost like

Mixed Rain Animal

Other Rain Animal

Hybrid Animals / Therianthropes

Mammal-like

- Eland Rhebok Gemsbok Elephant Wildebeest
- Indeterminate

Other Types of Mammal

Birdlike

- Ostrich Swallows Winged Human

Other Therianthrope Birdlike

Flying Antelope / Winged Creature

- Standing Kneeling Legless

Other Winged Creature

Symbolic Details

SITE ID

Therianthrope: Reptilian and Amphibious

Crocodile

Turtle

Tadpole

Eel

Other Reptilian

Therianthrope Combonation Details

Human Details

SITE ID

Anotomical Details

- Penis Erect Line through Penis Breast Protruding Buttocks
- Extended Labia Definite Face Definite Digits Hairstyle

Type of Face

- Transformed Body Elongated Body Elongated Limbs
- Extra Digits Less Digits
- Dots from Back of Neck Protrusions from Head With Whiskers

Clothing and Accesories

- Loin Cloth Cloak / Kaross Small Medium Large
- Apron / Skirt Front Back Feather Flywhisk
- Dance Sticks Rattle at Hand Rattle at Ankle
- Carry Bag Hand Bag Tassled Bag

Other Objects

Patterning

- Dots Crosses Zigzag Lines / Stripes
- With Magic Line Lines from beneath Arm Bandeliers Band

Other Pattern

Actions and Postures

- Sitting Squatting Walking Running
- Dancing Arms Outstretched Bent Forward Mastrubating
- Healing, Laying on Hands Giving Birth Bleeding from Nose
- Gathering Food Gathering Honey Carrying Game
- Killing Quiver, Bow and Arrow Drawn Bowstring
- Capture Rain Animal With wounded Animal

Specify Capture

Human Details

SITE ID

Other Action and Postures

Group Scenes

Dancing

Semicircular Circular Clockwise Anti Clockwise

Healing Initiation Women Men and Women

Men, Women and Children

On Move As Unit Confrontational Battle Raid

With Children

Couples Holding Hands Having Intercourse Fighting

Other Group Scenes

Object and Structure Details

SITE ID

Sticks

- Walking
- Dancing
- Staff
- Fire
- Digging Stick: Plain
- Digging Stick: Bored Stone

Weapons and Hunting Equipment

- Bow
- Arrow
- Club
- Spear
- Quiver
- Axe
- Guns

Music Instrument

- Rattles
- Flute
- Music Bow

Rope

- Snare
- Fishing Line
- Magic Line / Rope
- Net
- Ladder

Traps

- Pit
- Fish Trap
- Net

Fire

- Fire

Enclosure

- Fence
- Hut

Overhang or Cave

- Sideview
- Wallpegs or Hanging Bags
- People Relaxing
- People Dancing

Shapes

- Rainbow
- Sun
- Stars
- Cloud Burst
- Concentric Shapes
- Starburst

Other Shapes

Other Objects or Structures

Plant Details

SITE ID

- Bulb Reeds Aloe Tree Domesticates Mushrooms

Other Plants

Management Details

SITE ID

Significance High Medium Low

Reason

Priority High Medium Low

Reason

Threats High Medium Low

Reason

Damage Water Graffiti Fire Erosion or Exfoliation

Other Damage

Water located near or at Site? Water Location:

Management Details

Management Details

SITE ID

Assesment

Last Date Assesed by

Affiliation

Ownership and Authority

Land Owner

Contact Details

Local Authority

Contact Details

OpenSite

Access to Local Communities

Monitoring Process

Complete Detailed Description

SITE ID

Appendix 4 Questionnaire returns

Evaluation Questionnaire

Web-based GIS

This questionnaire should be conducted after reading and carrying out the exercises in the background document attached. It may be advantageous to read this questionnaire before doing the exercises to keep the questions in mind while operating the web-based GIS.

Name

Rika du Plessis

Organisation

Western Cape Nature Conservation / CapeNature

Physical Location

Cederberg Wilderness – 250km north of Cape Town – 30km south-east of Clanwilliam

Internet Connection (ie. 56k dial up, ISDN, ADSL, Wireless, Broadband or Other)

65k dial up, with Telkom microwaves. We don't have lines – work with Telkom substations.

On a rating of 1 to 5 did the welcome webpage download speedily. (1 being not at all and 5 being as fast as you would expect any page to download)

5 – normal download speed we experience

On a rating of 1 to 5 how easy was it to navigate from the welcome page to the activation of the web-based GIS (1 being exceptionally difficult and 5 being very easy)

5

Did the web-based GIS activate in a new window when requested? (Yes or No)

Yes

If No, describe what happened?

-

Did the web-based GIS appear as per the image in the background document? (Yes or No)

Yes

If No please do a screen save (press Shift and Print Screen simultaneously), open any image software (Paint etc.) and paste screen save. Save image in any format and please email it back to me with your questionnaire.

On a rating of 1 to 5 how do you rate the functionality of the web-based GIS with regards to rock art site management. (1 being not functional at all and 5 being very functional)

5

On a rating of 1 to 5 how useful do you think a web-based GIS would be to the aims and objectives of your organisation. (1 being not useful at all and 5 being very useful)

5

Are there any other datasets you would find useful within the context of a web-based GIS?

Powerlines
Telephonelines
Other Archaeological sites
Vegetation types
Geology

Please feel free to add any comments or criticisms you may have on the web-based GIS as a tool for rock art management.

This is a great tool for site management. For agencies not having access to Arcview GIS this web-based GIS will be usefull. But it is a management tool that need to be used regularly in order to get the full benifit

Evaluation Questionnaire

Web-based GIS

This questionnaire should be conducted after reading and carrying out the exercises in the background document attached. It may be advantageous to read this questionnaire before doing the exercises to keep the questions in mind while operating the web-based GIS.

Name Vicky Nardell

Organisation Independent Archaeological Consultant

Physical Location Presently in the UK

Internet Connection (ie. 56k dial up, ISDN, ADSL, Wireless, Broadband or Other)
Fast fast, broadband I think, public library, very quick!

On a rating of 1 to 5 did the welcome webpage download speedily. (1 being not at all and 5 being as fast as you would expect any page to download) 5

On a rating of 1 to 5 how easy was it to navigate from the welcome page to the activation of the web-based GIS (1 being exceptionally difficult and 5 being very easy) 4

Did the web-based GIS activate in a new window when requested? (Yes or No) Yes

If No, describe what happened?

Did the web-based GIS appear as per the image in the background document? (Yes or No) Yes

If No please do a screen save (press Shift and Print Screen simultaneously), open any image software (Paint etc.) and paste screen save. Save image in any format and please email it back to me with your questionnaire.

On a rating of 1 to 5 how do you rate the functionality of the web-based GIS with regards to rock art site management. (1 being not functional at all and 5 being very functional) 5

On a rating of 1 to 5 how useful do you think a web-based GIS would be to the aims and objectives of your organisation. (1 being not useful at all and 5 being very useful) 5 if expanded suitably across geographical locations

Are there any other datasets you would find useful within the context of a web-based GIS? Non-public info only

Please feel free to add any comments or criticisms you may have on the web-based GIS as a tool for rock art management. Amazing, never seen one like that before!

Evaluation Questionnaire

Web-based GIS

This questionnaire should be conducted after reading and carrying out the exercises in the background document attached. It may be advantageous to read this questionnaire before doing the exercises to keep the questions in mind while operating the web-based GIS.

Name

Jeremy C Hollmann

Organisation

Natal Museum

Physical Location

Pietermaritzburg

Internet Connection (ie. 56k dial up, ISDN, ADSL, Wireless, Broadband or Other)

On a rating of 1 to 5 did the welcome webpage download speedily. (1 being not at all and 5 being as fast as you would expect any page to download)

4

On a rating of 1 to 5 how easy was it to navigate from the welcome page to the activation of the web-based GIS (1 being exceptionally difficult and 5 being very easy)

5

Did the web-based GIS activate in a new window when requested? (Yes or No)

yes

If No, describe what happened?

Did the web-based GIS appear as per the image in the background document? (Yes or No)

yes

If No please do a screen save (press Shift and Print Screen simultaneously), open any image software (Paint etc.) and paste screen save. Save image in any format and please email it back to me with your questionnaire.

N/a

On a rating of 1 to 5 how do you rate the functionality of the web-based GIS with regards to rock art site management? (1 being not functional at all and 5 being very functional)

5 for those aspects of rock art management that are amenable to this kind of data manipulation.

On a rating of 1 to 5 how useful do you think a web-based GIS would be to the aims and objectives of your organisation. (1 being not useful at all and 5 being very useful)
5, potentially, with the crucial proviso that the data are accurate and up to date!

Are there any other datasets you would find useful within the context of a web-based GIS?

None that I can think of at the moment.

Please feel free to add any comments or criticisms you may have on the web-based GIS as a tool for rock art management.

Great potential, but the problem is always having up to date data in useful/accessible formats and with a good net connection.

Evaluation Questionnaire

Web-based GIS

This questionnaire should be conducted after reading and carrying out the exercises in the background document attached. It may be advantageous to read this questionnaire before doing the exercises to keep the questions in mind while operating the web-based GIS.

Name

Lori Wong

Organisation

Getty Conservation Institute

Physical Location

Los Angeles, CA USA

Internet Connection (ie. 56k dial up, ISDN, ADSL, Wireless, Broadband or Other)

Broadband

On a rating of 1 to 5 did the welcome webpage download speedily. (1 being not at all and 5 being as fast as you would expect any page to download)

5

On a rating of 1 to 5 how easy was it to navigate from the welcome page to the activation of the web-based GIS (1 being exceptionally difficult and 5 being very easy)

5

Did the web-based GIS activate in a new window when requested? (Yes or No)

Yes. Took a short while to load.

If No, describe what happened?

Did the web-based GIS appear as per the image in the background document? (Yes or No)

Yes.

If No please do a screen save (press Shift and Print Screen simultaneously), open any image software (Paint etc.) and paste screen save. Save image in any format and please email it back to me with your questionnaire.

On a rating of 1 to 5 how do you rate the functionality of the web-based GIS with regards to rock art site management. (1 being not functional at all and 5 being very functional)

4

On a rating of 1 to 5 how useful do you think a web-based GIS would be to the aims and objectives of your organisation. (1 being not useful at all and 5 being very useful)

5

Are there any other datasets you would find useful within the context of a web-based GIS?

Please feel free to add any comments or criticisms you may have on the web-based GIS as a tool for rock art management.

As a user with only a basic knowledge of GIS I'm always questioning the final output and use of a GIS to the overall investment of time (design and population of data). For example, in Ex2 you wouldn't really need a GIS and the buffering feature to see that the ranger station is located more than 100m from the sites. However, in general, I think this web-based GIS is very useful. I do wonder (and am very curious to know) if it will be accessible/understandable to people with no GIS background. In my opinion, GIS is not an intuitive or initially user-friendly tool! For example, the attribute table is a bit overwhelming and it is difficult to decipher the field names without the cheat sheet. It definitely requires the background document you attached and some basic idea of how GIS operates.

Additional minor comments:

- The campsite was difficult to find because it is so small!
- Some people may have a popup window blocker on that prevents the image window from opening.
- In the image windows only the site identifier came up. It would be nice to see the name of the site to associate it with the images.
- The videos took a long time to view.

Evaluation Questionnaire

Web-based GIS

This questionnaire should be conducted after reading and carrying out the exercises in the background document attached. It may be advantageous to read this questionnaire before doing the exercises to keep the questions in mind while operating the web-based GIS.

Name Frans Prins

Organisation Maloti Drakensberg Transfrontier Project

Physical Location Midmar Dam, Howick

Internet Connection (ie. 56k dial up, ISDN, ADSL, Wireless, Broadband or Other)
56k dial up and ADSL

On a rating of 1 to 5 did the welcome webpage download speedily. (1 being not at all and 5 being as fast as you would expect any page to download)

4

On a rating of 1 to 5 how easy was it to navigate from the welcome page to the activation of the web-based GIS (1 being exceptionally difficult and 5 being very easy)

4

Did the web-based GIS activate in a new window when requested? (Yes or No)

Yes

If No, describe what happened?

Did the web-based GIS appear as per the image in the background document? (Yes or No)

Yes

If No please do a screen save (press Shift and Print Screen simultaneously), open any image software (Paint etc.) and paste screen save. Save image in any format and please email it back to me with your questionnaire.

On a rating of 1 to 5 how do you rate the functionality of the web-based GIS with regards to rock art site management. (1 being not functional at all and 5 being very functional)

4

On a rating of 1 to 5 how useful do you think a web-based GIS would be to the aims and objectives of your organisation. (1 being not useful at all and 5 being very useful)

4

Are there any other datasets you would find useful within the context of a web-based GIS?

Yes, number and intensity/use of visits to rock art/living heritage sites – annually

Please feel free to add any comments or criticisms you may have on the web-based GIS as a tool for rock art management.

I think that it is a fantastic tool, however, it make sense to implement this tool first at the “public rock art sites” and proposed “public rock art sites” i.e. Game Pass, Main Caves, Battle Cave, Good Hope, Segubudu, Brotherton, Lower Mushroom, and Procession shelter. These sites have a large visitor and site-use number/percentage. It will be a fantastic tool for the relevant OIC’s to use and update (with Natal Museum and Amafa guidance) and their efforts will also aid with the monitoring of these sites – so important in the management plans of these areas. For this tool to be of real applied use to heritage managers it need to be developed in line with “management and conservation plans” for sensitive sites and areas. Of course the approach should be much broader and cover many more areas, not just sensitive sites, when used as a research (i.e. heuristic research) tool.

Evaluation Questionnaire

Web-based GIS

This questionnaire should be conducted after reading and carrying out the exercises in the background document attached. It may be advantageous to read this questionnaire before doing the exercises to keep the questions in mind while operating the web-based GIS.

Name Rand Eppich

Organisation The Getty Conservation Institute

Physical Location Los Angeles, California

Internet Connection (ie. 56k dial up, ISDN, ADSL, Wireless, Broadband or Other)

T1

On a rating of 1 to 5 did the welcome webpage download speedily. (1 being not at all and 5 being as fast as you would expect any page to download)

5

On a rating of 1 to 5 how easy was it to navigate from the welcome page to the activation of the web-based GIS (1 being exceptionally difficult and 5 being very easy)

5

Did the web-based GIS activate in a new window when requested? (Yes or No)

yes

If No, describe what happened?

Did the web-based GIS appear as per the image in the background document? (Yes or No)

??

If No please do a screen save (press Shift and Print Screen simultaneously), open any image software (Paint etc.) and paste screen save. Save image in any format and please email it back to me with your questionnaire.

On a rating of 1 to 5 how do you rate the functionality of the web-based GIS with regards to rock art site management. (1 being not functional at all and 5 being very functional)

3 – a good tool

but will you build in training for the site managers?

I don't think they can be expected to read the instructions

On a rating of 1 to 5 how useful do you think a web-based GIS would be to the aims and objectives of your organisation. (1 being not useful at all and 5 being very useful)

2 – will be useful but must be built into a project

Are there any other datasets you would find useful within the context of a web-based GIS?

Any other heritage management project

Please feel free to add any comments or criticisms you may have on the web-based GIS as a tool for rock art management.

Good project... loaded quickly... easy to get around - impressive
a few suggestions:

- 1) you must populate with more data... it was difficult to find and had to turn off all layers to find. Possibly making the sites appear first... and make the user turn the contours on if they need.
- 2) Also maybe customizing pre-programming (Query) a few buttons... such as... show me the sites that have the highest significance and must be protected.
- 3) Explain to the user how much time this took you... an important evaluation criteria... if this cost you 2000 hours it may not work for some sites – but if it only took you 5.. well
- 4) Also explain the costs and equipment required... are you running a dedicated mapserver machine? What kind of connection do you have at your end? Also build in the cost for data population
- 5) How will the information that is collected in the field find its way into the database?
- 6) Can you add a download photos button
- 7) Some of the hotlinks didn't work... would be great to click on the map and have the "representative" image appear on top of the map

Evaluation Questionnaire

Web-based GIS

This questionnaire should be conducted after reading and carrying out the exercises in the background document attached. It may be advantageous to read this questionnaire before doing the exercises to keep the questions in mind while operating the web-based GIS.

Name Justine Wintjes

Organisation Amafa aKwaZulu-Natali

Physical Location 195 Longmarket Street, Pietermaritzburg

Internet Connection (ie. 56k dial up, ISDN, ADSL, Wireless, Broadband or Other)

56k

On a rating of 1 to 5 did the welcome webpage download speedily. (1 being not at all and 5 being as fast as you would expect any page to download)

5

On a rating of 1 to 5 how easy was it to navigate from the welcome page to the activation of the web-based GIS (1 being exceptionally difficult and 5 being very easy)

5

Did the web-based GIS activate in a new window when requested? (Yes or No)

Y

If No, describe what happened?

-

Did the web-based GIS appear as per the image in the background document? (Yes or No)

Y

If No please do a screen save (press Shift and Print Screen simultaneously), open any image software (Paint etc.) and paste screen save. Save image in any format and please email it back to me with your questionnaire.

On a rating of 1 to 5 how do you rate the functionality of the web-based GIS with regards to rock art site management. (1 being not functional at all and 5 being very functional)

3.5

On a rating of 1 to 5 how useful do you think a web-based GIS would be to the aims and objectives of your organisation. (1 being not useful at all and 5 being very useful)

5

Are there any other datasets you would find useful within the context of a web-based GIS?

Cattle paths

Incidence of graffiti*

Physical condition of rock art

Physical integrity of site

Presence of archaeological deposits / surface artefacts

Excavated sites*

Frequency of hikers

* Not applicable for the Valley of Pools but can be used elsewhere

Please feel free to add any comments or criticisms you may have on the web-based GIS as a tool for rock art management.

Potentially a very powerful tool for rock art site (and other kinds of heritage - cultural, palaeontological, geological etc.) management. It already contains a vast amount of data and has the flexibility to be elaborated as needed.

Even on a slow dial-up connection (56k) this site was user-friendly and did not require unreasonable waiting time.

A key issue will be to ensure that the database is maintained, expanded as necessary and accessible to professionals. Amafa aKwaZulu-Natali is very encouraging of this initiative and would be prepared to contribute time and resources in order to see it fully implemented.

Evaluation Questionnaire

Web-based GIS

This questionnaire should be conducted after reading and carrying out the exercises in the background document attached. It may be advantageous to read this questionnaire before doing the exercises to keep the questions in mind while operating the web-based GIS.

Name: Sian Tiley-Nel, Curator & Archaeologist

Organisation: University of Pretoria, Mapungubwe Museum

Physical Location: University of Pretoria Mapungubwe Museum Old Arts Building room 2 – 4 Lynnwood Road, Pretoria 0002

Internet Connection (ie. 56k dial up, ISDN, ADSL, Wireless, Broadband or Other)

Netscape Navigator

On a rating of 1 to 5 did the welcome webpage download speedily. (1 being not at all and 5 being as fast as you would expect any page to download)

5

On a rating of 1 to 5 how easy was it to navigate from the welcome page to the activation of the web-based GIS (1 being exceptionally difficult and 5 being very easy)

5

Did the web-based GIS activate in a new window when requested? (Yes or No)

No

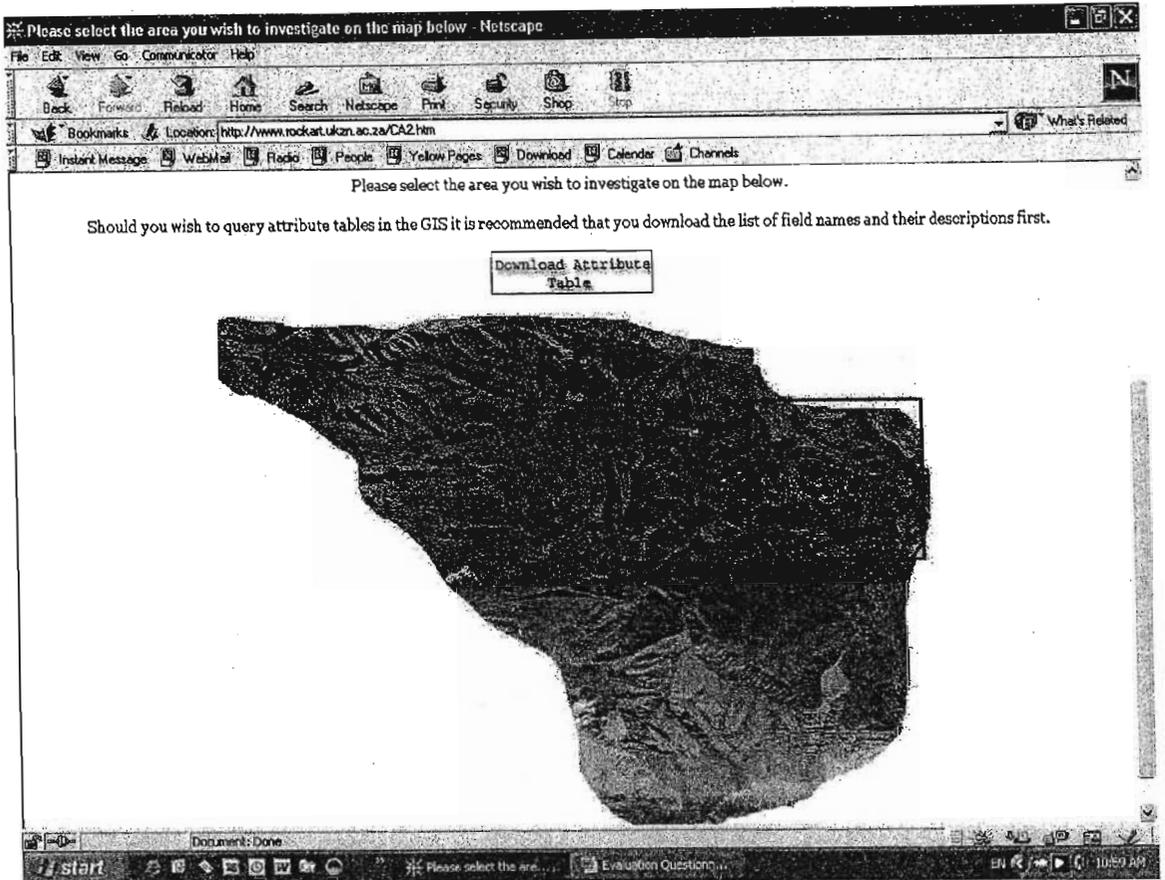
If No, describe what happened? Not sure would not allow me to enter or view, the message read as follows

This viewer makes extensive use of JavaScript and DHTML. A Browser that is compatible with either Internet Explorer 5.0 (and newer) or Netscape 6.0 (and newer) is required to view it.

Did the web-based GIS appear as per the image in the background document? (Yes or No)

No

If No please do a screen save (press Shift and Print Screen simultaneously), open any image software (Paint etc.) and paste screen save. Save image in any format and please email it back to me with your questionnaire.



Sorry not sure about your directions to screen save, do not know how. I cannot go further than the above otherwise the message

On a rating of 1 to 5 how do you rate the functionality of the web-based GIS with regards to rock art site management. (1 being not functional at all and 5 being very functional)

Not applicable could not view

On a rating of 1 to 5 how useful do you think a web-based GIS would be to the aims and objectives of your organisation. (1 being not useful at all and 5 being very useful)

In terms of a resource for the University of Pretoria, the web-based GIS would be very beneficial especially to the Dept of Geography and those GIS modules offered to post graduate students. Unfortunately, the UP Department of Archaeology does not offer Rock Art as a subject and may not use the web-based GIS. My organisation, the Mapungubwe

Museum would not use it, as it does not relate directly to any of the museum's themes or functions, however Mapungubwe National Park also a Transfrontier Park should definitely find this useful and perhaps have their own developed.

Are there any other datasets you would find useful within the context of a web-based GIS?

Please feel free to add any comments or criticisms you may have on the web-based GIS as a tool for rock art management.

1. The text for the image of the entire Maloti Drakensberg Transfrontier Park is far too dark and small font, not legible enough.
2. Attribute table downloaded quickly and efficiently, no problems there.
3. I would recommend that you place a direct link to the webpage on your email that you sent out for people to view the site and pass comment.

Regards
Sian Tiley-Nel

Evaluation Questionnaire

Web-based GIS

This questionnaire should be conducted after reading and carrying out the exercises in the background document attached. It may be advantageous to read this questionnaire before doing the exercises to keep the questions in mind while operating the web-based GIS.

Name Douglas van Zyl

Organisation Ezemvelo KZN Wildlife

Physical Location uKhahlamba Regional Office, Midmar Dam

Internet Connection (ie. 56k dial up, ISDN, ADSL, Wireless, Broadband or Other)

ISDN

On a rating of 1 to 5 did the welcome webpage download speedily. (1 being not at all and 5 being as fast as you would expect any page to download)

4

On a rating of 1 to 5 how easy was it to navigate from the welcome page to the activation of the web-based GIS (1 being exceptionally difficult and 5 being very easy)

4

Did the web-based GIS activate in a new window when requested? (Yes or No)

Yes

If No, describe what happened?

Did the web-based GIS appear as per the image in the background document? (Yes or No)

Yes

If No please do a screen save (press Shift and Print Screen simultaneously), open any image software (Paint etc.) and paste screen save. Save image in any format and please email it back to me with your questionnaire.

On a rating of 1 to 5 how do you rate the functionality of the web-based GIS with regards to rock art site management. (1 being not functional at all and 5 being very functional)

3

On a rating of 1 to 5 how useful do you think a web-based GIS would be to the aims and objectives of your organisation. (1 being not useful at all and 5 being very useful)

5

Are there any other datasets you would find useful within the context of a web-based GIS?

Vegetation types, land-use zones, fire history

Please feel free to add any comments or criticisms you may have on the web-based GIS as a tool for rock art management.

Very useful, ability to capture data by a remote user would be very useful (subject to control and security)

Some of this information is very sensitive and access (and appropriate security) needs to be carefully controlled). Central repository for rock art data accessible to all users long overdue.

Appendix 5 Project media coverage

1

Ancient footprints uncovered

Latest discoveries confirm Drakensberg's geological history pre-dates Jurassic period



Earth window

by Tony Carnie

SCIENTISTS filming the rock art galleries of the Drakensberg uKhahlamba mountains have discovered the ancient footprints of a three-toed dinosaur and dozens of previously unknown Bushman paintings.

Each footprint is about half a metre long and they are unusual because they are negative prints.

Normally fossilised footprints are visible as depressions in a rock, whereas the Cathedral Peak prints protrude outwards from the rock surface. Gary Brower, the archaeologist who found them, explained that the layers of bedrock below the prints had collapsed, leaving the dinosaur's footmarks suspended in time above a rocky overhang.

The discovery was made by members of the Rock Art Mapping Project, which is led by Carl Grossman of the University of KwaZulu-Natal.

The aim of the multi-million mapping project is to create a specialist library of digital photographs of the Berg's rich history of rock art.

Once all the photographs have been captured and stashed away in a fire-proof safe they will be available with mapping co-ordinates to approved researchers.

There are more than 500 rock art sites in the park, with about 35 000 individual paintings. Many are deteriorating rapidly and part of the rationale for the photographic mapping project is to preserve them on film.

Grossman, from the university's Geomatics (Land Surveying) Department, said there were just more than 140 known sites in the Cathedral Peak area – yet within the space of a week, researchers managed to find six new sites in the Didima Gorge alone.

The researchers have been in the field for more than a year and have found 70 new sites – a staggering 48% increase in known sites in that area.

"So far, we have only explored 23% of the Cathedral Peak conservation area – so if this level of discovery is



MEMBERS of the Rock Art Mapping Project set up their theodolite and GPS equipment, on a mountain ridge near Cathedral Peak, to record the exact position of one of the newly-discovered Bushman painting sites. Team members include Patrick Khumalo, Kwanele Mbatha, Sandile Zuma, S'boniso Dube and Bheki Hlongwane. (Inset) The footprints from the past are located on a rocky overhang about 12m above the ground.

extrapolated to the entire uKhahlamba-Berg we can expect the discovery of new sites numbering in the thousands. This would be a huge addition to our natural heritage."

The dinosaur print discoveries will also add to the geological mystique of the Drakensberg region, which is a translation of the Afrikaans "dragon mountains".

Roger Porter, of Ezemvelo KZN Wildlife, said although there were two other dinosaur footprint sites in the Berg – at Giants Castle and at Elliot in the Eastern Cape – the latest discovery confirmed that the park's geological history pre-dated the Jurassic period, when Tyrannosaurus Rex and other giant lizards roamed the Earth.

"People have alluded to the mountain peaks' resemblance to the back of the dragon. The mist, clouds and lightning storms have also been compared to a puffing, fire-breathing dragon," he said.

Porter said the exact reasons for the rapid decay of several rock art sites was still unclear, although there were theories that changing land

uses and vegetation cover altered the humidity of soil and rock.

Some researchers speculated that the most recent paintings tended to deteriorate faster because more modern paints were different to earlier recipes, which contained mixtures of animal fats.

Grossman said the increase in veld fires could also be causing more dam-

age, while there was also concern about the impact of air pollution.

The project has been funded so far by the Lottery Distribution Trust Fund. The project team is working closely with Ezemvelo KZN Wildlife and staff from the Natal Museum, the Amafa aKwaZulu Natali heritage body and the Rock Art Research Institute of Wits University.



Ancient footprints found in Berg

BY TONY CARRIE

The ancient footprints of a three-toed dinosaur and dozens of previously unknown Bushman paintings have been discovered.

The findings were made by scientists filming the rock art galleries of the Drakensberg/uKhahlamba mountains in the Cathedral Peak area of KwaZulu Natal.

Each footprint is about half a metre long. They are unusual because they are "negative" prints.

Normally, fossilised footprints are visible as depressions in a rock, whereas these protrude outwards from the rock surface.

According to archaeologist Gary Trower, the layers of bedrock below the prints had collapsed, leaving the dinosaurs' footmarks suspended in time above a rocky overhang.

The discovery was made by members of the Rock Art Mapping Project led by Carl Grossman of the University of KwaZulu Natal.

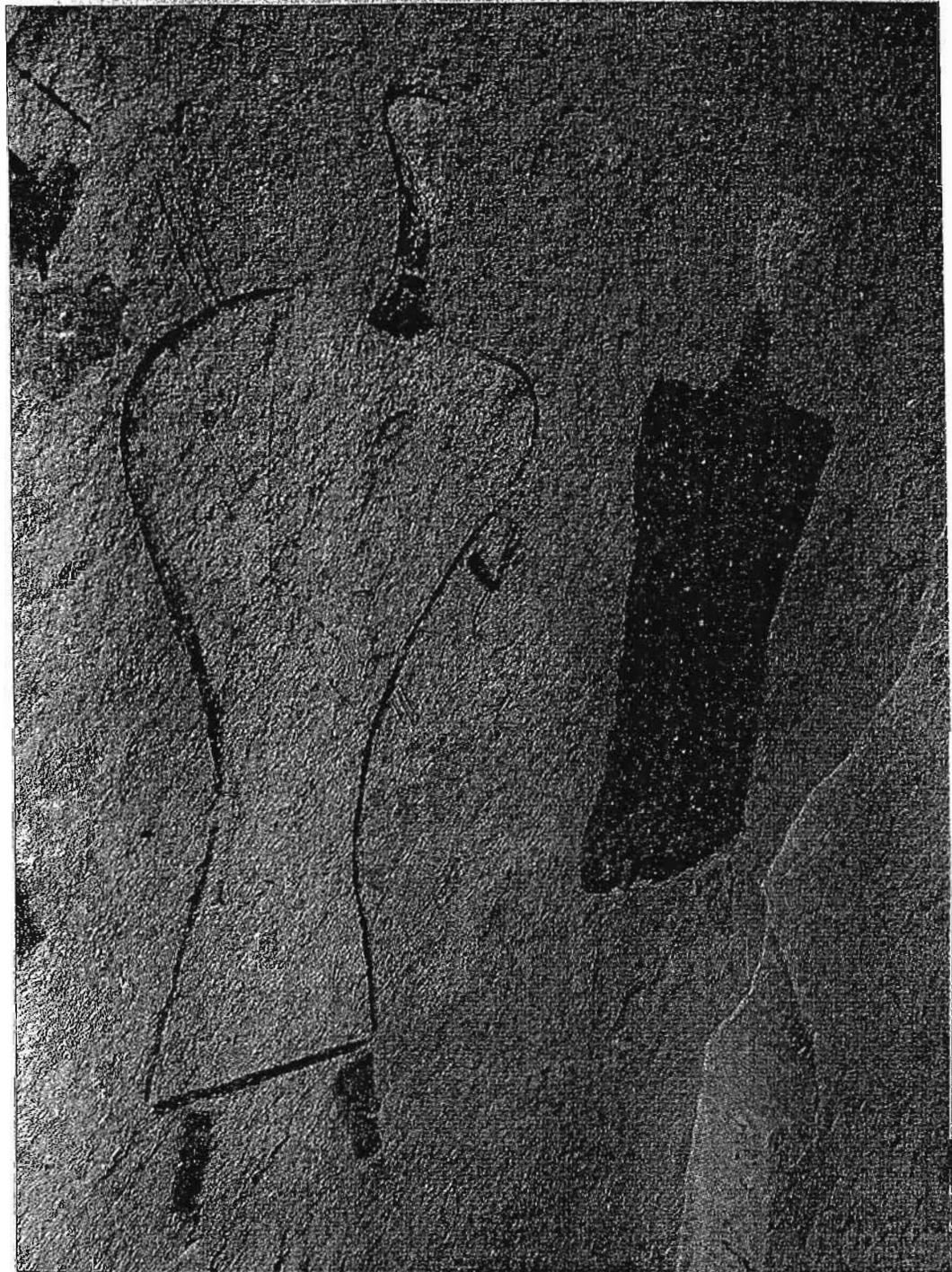
The aim of the multi-million-rand project was to create a specialist library of digital photographs of the Berg's rich rock art history.

Once all photographs have been captured and stashed away in a fire-proof safe, they will be available, with mapping co-ordinates, to approved researchers.

There are more than 500 rock art sites in the area, with about 35 000 individual paintings.

Many are deteriorating rapidly, and part of the rationale for the photographic mapping project is to preserve them on film.

Grossman, from the university's geomatics (land surveying) department, said there were just over 140 known sites in the Cathedral Peak area - yet within a week, researchers



Question of style ... one of the Bushman paintings found in the Drakensberg recently

found six new sites in the Didima Gorge alone.

Researchers spent more than a year in the field, during which time they found 70 new sites - a staggering 48% increase in the area's known sites.

Only 23% of the Cathedral Peak conservation area has been explored so far.

Roger Porter of Ezemvelo KZN Wildlife said the latest dinosaur discovery confirmed that the park's geological history predated the Jurassic period, when Tyrannosaurus Rex and other giant lizards roamed the Earth.



On a mission ... members of the Rock Art Mapping Project

Ancient footprints found in Drakensberg

Tony Carnie
December 09 2004 at 05:04 AM

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The ancient footprints of a three-toed dinosaur and dozens of previously unknown Bushman paintings have been discovered.

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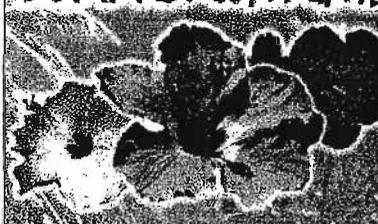
■ This article was originally published on page 3 of The Star on December 09, 2004

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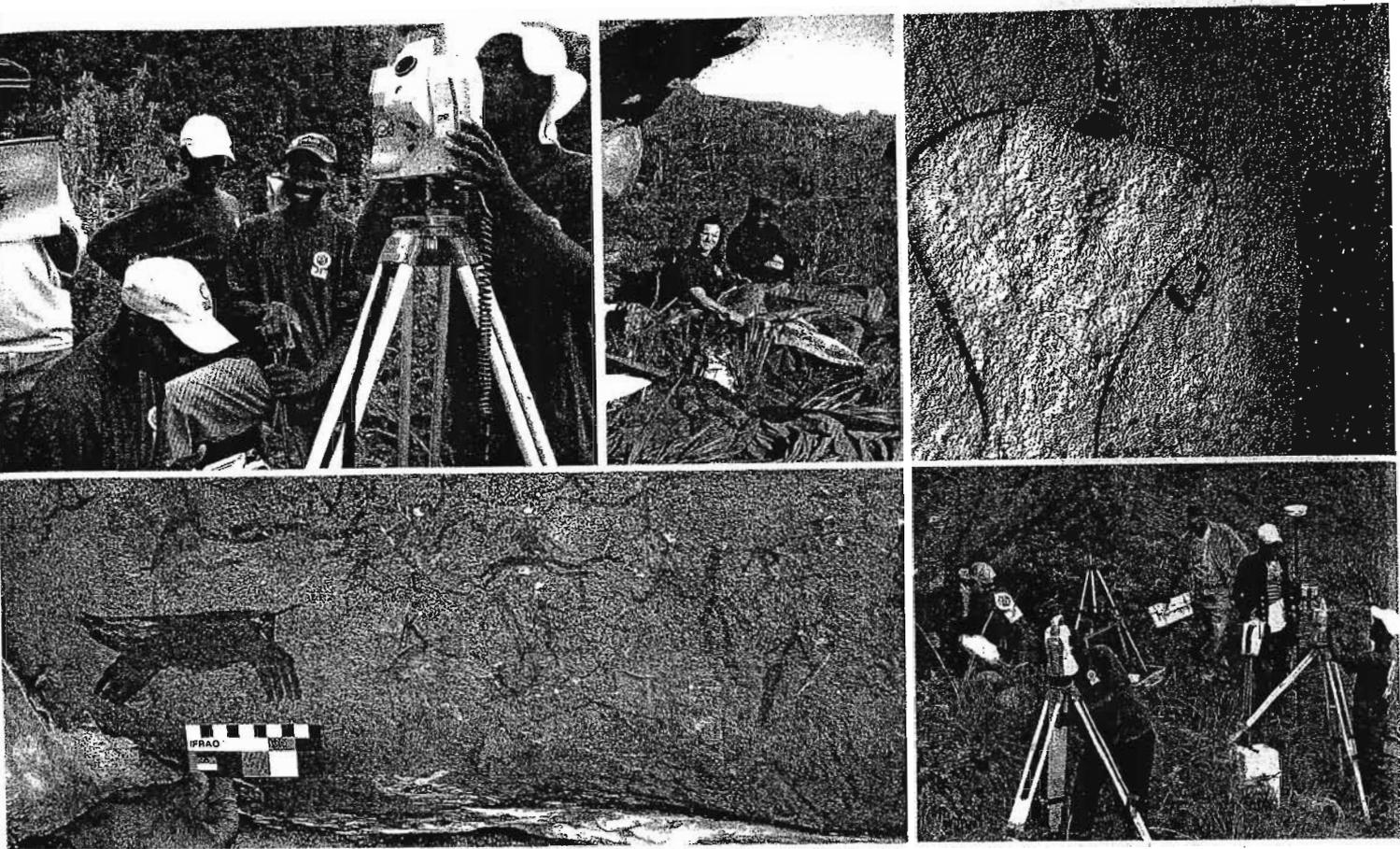
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THE DREAM PAINTERS

By Rory Cruickshank-Marten

The San people left a prodigious legacy of their 'dreams' and culture in the form of rock paintings. The dominant theory regarding these magnificent paintings is where the images are understood to record experiences of their religious rituals and experiences while in a trance. Recent testing has shown the paintings to be approximately 3000 years old, although some are as recent as the late 19th Century.

There are some 40 000 images at about 600 sites in the uKhahlamba-Drakensberg Park alone. This makes it the largest and richest concentration of rock paintings in Africa. With 143 'known' sites in the Didima-Cathedral Peak area it in turn makes an appropriate springboard for the Rock Art Mapping Project (R.A.M.P.). This region is visited by thousands of tourists and as a World Heritage Site, traffic is likely to increase. Without a defined database of sites irreparable damage could be and has been done and a priceless part of South Africa's valuable heritage lost forever.

One of the biggest problems in the conservation of Rock Art is that of the so-called 'known' sites. From 1920 to the 1990's geographic positions were not accurately recorded and some sites have been found to be even hundreds of metres out or non-existent, which necessitates new searches rendering a large proportion to be virtually new sites and some have been lost or destroyed both by natural phenomena and human impacts.

Over the last 30 years many observers have noted that paintings have visibly deteriorated. It is still open for speculation whether this is due to climate, pollution, human damage or simply natural deterioration in the rocks or the chemical constituents of the paints. What manufacturer can make a paint lasting 3000 years in the open?

R.A.M.P. is also turning up many more sites of rock art and other interests. When the team started work in the Cathedral Peak a year ago, there were 143 'known' sites. The team has added a further 76 or a staggering 52.8%. Of

ROCK ART MAPPING PROGRAMME

Through the fieldwork of R.A.M.P. the digital documentation of the Park is underway and consists of the following components for each rock art site:

- A set of six or more aerial photographs taken from a fixed geographic position which is recorded with accuracy.
- Detailed topographic stored in a Microsoft Access database.
- Surveyed points are recorded and stored.
- Coloured digital photographs of the rock art are taken and georeferenced to the topographic mosaic. The data are stored in a Microsoft Access database to ensure preservation of the current state forever.
- Digital 3D degree videography is done.
- Digital topographic maps are surveyed of each site which are also in a downloadable .pdf format.
- A digital 3D georeferenced map through models developed.

In all this provides a permanent safeguard and record of the rock art as it is now. Research and education data can be accessed with the click of the mouse.

these 37 are new painting sites, 36 are new archaeological sites with Stone and Iron Age artifacts, and three are palaeontological sites with Dinosaurs footprints and bones. What is unique about these rare Dinosaur finds is that they are negative footprints visible on the roofs of the respective overhangs. This came about because the footprints were pressed into a layer, which became a rock stratum and was filled in by a subsequent overlay stratum. The original stratum underneath has fallen away over the eons leaving the top layer with "footprints" on its underside. These findings are tracks of three-toed giants that roamed this area and were discovered in a remote ravine by Gary Trower, the project's exploration archaeologist.

The Rock Art Mapping Project run by the Programme of Geomatics of the University of KwaZuluNatal is lead by Angus Forbes and is managed by Carl Grossman. It is presently funded by the National Lottery Distribution

Trust Fund. The team works closely with Ezemvelo KZN Wildlife, the Natal Museum, akwaZuluNatali (the heritage body for kwaZuluNatal) and the Rock Art Institute of Wits University.

The next phase of the project is subject to desperately needed funding. Besides continuing the mapping phases it will create an internet-based virtual reality experience for tourists and the public via the web on interactive machinery or computers at the Natal Museum and later the Rock Art Interpretation Centre. R.A.M.P. will provide a statistical and geographical backbone on which to base further research, management and conservation as well as the means to monitor short and long term changes. Because of the digital format of the information further analyses and interpretations can be done. The database can easily be updated whilst comparative records of physical condition of paintings can be done with ease. **W**

Wildside Fact Tracker

From the new Didima Rest Camp there are hikes available to places such as Rainbow Gorge or to some of the major Rock Art galleries under supervisory leadership of Ezemvelo's KZN Wildlife's specially trained community guides.

USEFUL CONTACT NUMBERS

Durban Rambler's Hiking Club
(031) 764 4721

Mountain Backpackers Club
(031) 266 3970

Mountain Club of South Africa
082 4661731 or 082 920 2287

Hiking SA
(011) 3206174

ROCKART MAPPING PROJECT

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Tel: (031) 2601062
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